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ENFOR PROJECT P

ENFOR Project P-245
Digest of Publications and Reports of the ENFOR Production Program

by

Dendron Resource Surveys Ltd.

Contractor's Final Report
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ENFOR Project P-245
Digest of
Publications and Reports
of the
ENFOR Production Program

by

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ABSTRACT

This report presents abstracts and brief comments on publications and reports issued under the ENFOR Production Program, as well as brief notes on projects for which no reports are available. ENFOR Production Program projects are also listed and classified by subject matter and geographic area of relevance.

1. INTRODUCTION

This report is a guide for those who wish to make use of the results, publications and reports produced by the "Energy from the Forest" (ENFOR) Production Program. The publications and contractor's reports available at the time of writing (January 1983) will be described, listed and classified by subject matter, by the geographic area to which they apply, and by the ENFOR Project to which they belong. The present report is part of a larger assignment which also involved a review of program content and objectives.

ENFOR is a research, development and demonstration program sponsored by the Government of Canada and aimed at substituting forest biomass for non-renewable fuels. It comprises two distinct sub-programs: Biomass Production, which deals with forest-oriented matters that relate to raw material supply, and Biomass Conversion, which is concerned with the transformation of forest biomass into energy, prepared fuels, or energy-intensive chemicals. Both sub-programs are the responsibility of the Canadian Forestry Service (CFS), Department of the Environment, although it is proposed that the Department of Energy, Mines and Resources will assume responsibility for the Conversion Program.

The present report is concerned only with the Biomass Production Program, which has four objectives:

a) Biomass availability: To determine the amount of biomass in Canadian forests, and to estimate its potential contribution to the nation's energy requirements.

b) Biomass harvesting: To develop and test methods and systems of harvesting, processing and delivering forest biomass for conversion to energy or fuels.

c) Environmental impacts: To assess the environmental impacts of intensified biomass production and harvesting for energy purposes.

d) Intensive silviculture: To develop and test methods and systems for increasing biomass production.

The following pages make several references to these objectives in describing the publications and reports of the ENFOR Production Program. A schematic diagram (Figure 1) shows how these activities are connected in the production of forest biomass for energy.

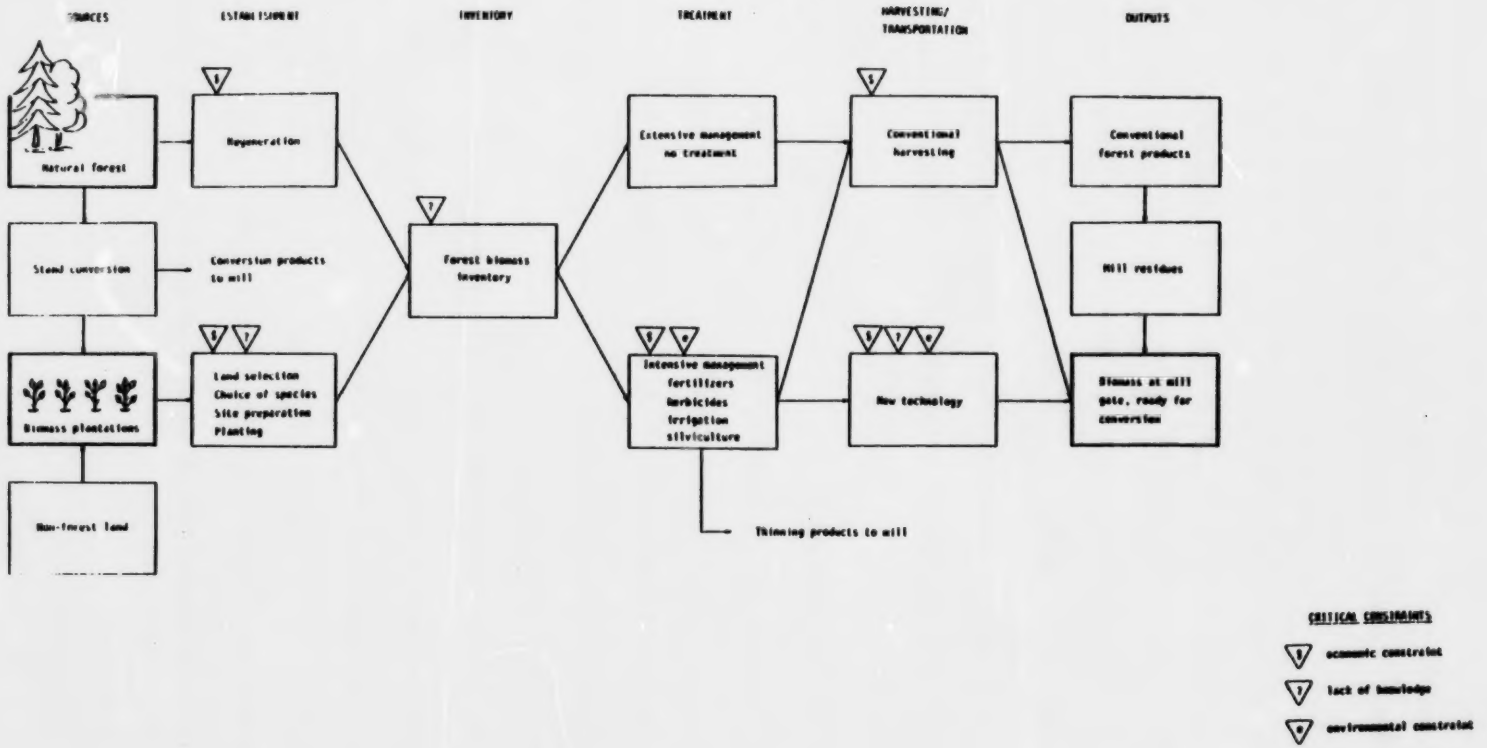

Figure 1. The Biomass Production System

2. SOURCES OF INFORMATION ON THE ENFOR PRODUCTION PROGRAM

The distribution of information is of great importance to the ENFOR Program because the benefits from the Program are often expected to be realized through the dissemination of knowledge and experience gained from individual projects. Persons interested in the program can therefore expect to receive considerable help from the CFS agencies involved. Before commencing a search for reports and other information it is, however, well worthwhile to review some relevant aspects of the organization of the Program.

2.1 Responsible establishments

ENFOR projects are completed by the CFS through contracts with private and public institutions and through studies carried out at regional and headquarters establishments of the CFS. Program activities are coordinated by an ENFOR Secretariat, located in Hull, Quebec, but most projects are the responsibility of CFS establishments located in different regions of Canada.

The ENFOR Secretariat is a good source of general information, but details on individual projects, as well as project reports, are best obtained from the responsible establishment. Establishments involved in specific projects are shown in the project list in Appendix 1,

and relevant addresses are given in Appendix 2. The Forest Engineering Institute of Canada (FERIC) and the Canadian Wildlife Service are also included in these lists because they have been given considerable independence in completing projects assigned to them. FERIC, an organization supported by government and industry, was a large contractor under ENFOR; it has engaged several sub-contractors and issues its own publications.

2.2 ENFOR projects

Activities of ENFOR are organized into "projects". Each project has a number which carries the prefix "P" if it is a project in the ENFOR Production Program and "C" if it lies in the ENFOR Conversion Program. Project numbers, which are shown in the list of projects in Appendix 1, were issued more or less consecutively; some numbers are missing because a few planned projects were cancelled, and occasionally one project was divided between two project numbers. Nevertheless, projects and especially project numbers, are the method of referring to any piece of work within ENFOR.

Project titles give a useful indication of project content, but the reader will encounter some inconsistencies which usually have arisen because the title of the final report is not the same as that used when the project was first announced. There are not official project titles for Appendix 1; we have simply chosen the version which best describes the project content.

2.3 ENFOR publications and reports

ENFOR publications, which all carry the distinctive ENFOR logo, come in several series and forms:

a) The ENFOR Secretariat issues the "ENFOR Review", usually twice a year. This bilingual publication describes ENFOR objectives and carries lists of ENFOR projects and abstracts of recent projects. Copies are available from the ENFOR Secretariat (see Appendix 2).

b) The most important results appear in the Published Reports of the ENFOR Program. Most are produced with distinctive orange covers indicating their association with ENFOR, but as far as formal reference is concerned, they are part of the series of publications of the establishment which issued them. Many are "Information Reports" of regional CFS establishments and others, for example, appear as Special Reports of the Forest Engineering and Research Institute of Canada. The exact descriptions are given with the abstracts of Appendix 3.

c) Many reports on ENFOR projects are issued as "Contractor's Reports" and are available from the responsible establishments. In general, these are interim reports or results that were not of sufficiently wide interest to warrant publication. "Contractor's Reports" are produced in orange covers that are similar to those of ENFOR publications, but they can be recognized by a cut-out window in the cover; these reports are not part of a numbered series, but are referred to

by ENFOR Project Number or Contract Number.

d) In addition, there is a large number of miscellaneous publications and articles which scientists associated with the Program have contributed to various seminars or scientific journals. Several ENFOR projects, notably P-8, P-9, P-15, P-40, and P-150, include substantial literature reviews which are useful in locating this material.

2.4 Locating and obtaining ENFOR publications and reports

A person interested in locating ENFOR Production Program information on a specific topic could begin by skimming over the list of projects given in Appendix 1. If a project appears relevant, then the reader should note the ENFOR Project Number. Detailed references to available reports are then arranged by Project Number in Appendix 3, together with an abstract and reviewer's comments, which may give useful information. Appendix 1 also shows the establishment from which the report in question can be obtained. Addresses of these establishments and of the ENFOR Secretariat from which some reprints can be ordered are given in Appendix 2.

Another approach to finding reports on a given topic is to refer to Tables 1, 2, and 3 which list projects by subject matter, by geographic area of application, and by the tree species studied. Once a project has been identified in these tables, detailed notes on the project can be found in Appendix 3.

Caution is, however, in order in using Tables 1 and 2 because both classifications involve very subjective decisions. Also, only the main subject areas are mentioned in Table 1. For example, most harvesting studies involve some economics, but are not classified under that topic.

Table 1

Classification of Projects by Subject

Subject	Project Number
1. General	
a) Planning, objectives, policy	1, 11, 15, 28.4, 245
b) Socio-economic studies	2, 25, 28.4, 135, 157, 184, 207, 224
2. Biomass availability	
a) Development of methodology	4, 14, 15, 20, 22, 28.1, 30.1, 30.2, 38, 40.2, 41, 66, 92, 112, 140, 141, 142, 144, 146, 148, 158, 159, 169, 179, 186, 190, 219, 225, 227, 234, 236, 240, 242, 246, 247
b) Estimation of supply	1, 6, 21, 23, 25, 28.1, 140, 146, 148, 157, 224, 227, 228, 238, 242
3. Growth and yield studies	
a) General reviews, growth models	16, 22, 51, 64, 78, 102, 150
4. Intensive silviculture	
a) General	15, 30.2, 139
b) Silvicultural treatments	
i) Intensive culture, plantations	10, 75, 121, 154, 172, 193, 194
ii) Fertilization & nitrogen fixation	9, 78, 121, 194, 198, 232, 248
iii) Regeneration, reforestation	145, 184, 193
c) Development of planting equipment	67

Table 1, continued

Subject	Project Number
5. Biomass harvesting and transportation	
a) Reviews, cost summaries	15, 19, 25, 28.4, 59, 157, 162, 224, 237
b) Operational trials & production studies	28.2, 36, 39, 54, 115, 143, 152, 163, 184, 189, 191, 207
c) Development of new equipment	27, 28.2, 28.3, 183, 201, 210, 215, 216, 223, 231, 243
6. Environmental impact	
a) General theory and studies	71, 95, 155, 197, 199
b) Nutrient budget	8, 9, 40.1, 40.2, 138, 199, 205, 233
c) Climatic effects	149, 150
d) Wildlife	164, 170, 203, 226
7. Conversion of biomass	
a) Theory and cost summaries	59, 207, 228

Table 2

Classification of Projects by Geographic Relevance *

Area of Relevance	Project Number
1. One province or territory	
Newfoundland	1, 2, 112, 115, 143, 145, 146, 190, 191, 240, 242
Nova Scotia	247
New Brunswick	238
Prince Edward Island	189
Quebec	6, 157, 225, 236
Ontario	20, 21, 30.1, 30.2, 179, 228, 234
Manitoba	-
Saskatchewan	-
Alberta	23, 28.4, 205
British Columbia	25, 28.9, 36, 135, 142, 162, 183, 184
Northwest Territories	169
Yukon	141, 246
2. Regional	
Atlantic/Maritime	4, 38, 39, 40.2, 41, 158, 159, 172, 186
Quebec/Ontario	19, 121, 138, 152, 226
Western	22, 51, 92, 102, 169, 207
3. Two or more regions or all Canada	10, 11, 15, 16, 27, 28.2, 28.3, 28.7, 28.8, 28.10, 54, 59, 67, 75, 139, 140, 144, 149, 150, 154, 155, 163, 164, 170, 193, 194, 201, 203, 210, 215, 216, 219, 223, 224, 227, 231, 233, 237, 242, 243, 248
4. No specific geographic relevance: general studies, basic research	8, 9, 14, 28.1, 28.5, 28.6, 28.11, 28.12, 40.1, 64, 66, 71, 78, 95, 148, 197, 198, 199, 232, 245

* Note: Projects are listed only once. For example, a study confined to one province is not repeated under "Regional".

Table 3

Classification of Projects by Species Group

Species Group Studied	Project Number
1. Coniferous	4, 10, 19, 20, 23, 25, 28.3, 28.4, 28.8, 40.2, 41, 51, 54, 75, 92, 112, 141, 145, 158, 169, 179, 186, 190, 225, 236, 238, 240, 246
2. Deciduous	4, 10, 19, 21, 22*, 25, 28.3, 28.8*, 30.1*, 30.2*, 38, 39, 40.1*, 40.2*, 41, 51*, 67*, 75, 78, 92, 102*, 112*, 121*, 138, 139*, 141, 143, 152, 154, 159, 163*, 169, 172, 186, 190, 193*, 194, 205*, 207*, 232, 234, 236, 238, 240, 246, 248*
3. No specific reference to species groups	1, 2, 6, 8, 9, 11, 14, 15, 16, 27, 28.1, 28.2, 28.5, 28.6, 28.7, 28.9, 28.10, 28.11, 28.12, 36, 59, 64, 66, 71, 95, 115, 135, 140, 142, 143, 144, 146, 148, 149, 150, 155, 157, 162, 164, 170, 183, 184, 189, 191, 197, 198, 199, 201, 203, 210, 215, 216, 219, 223, 224, 226, 227, 228, 231, 233, 237, 242, 243, 245, 247

*Studies concerned with poplars.

APPENDIX 1

List of Biomass Production Projects

List of Biomass Production Projects

Project No. (Responsible Establishment)*	Subject
P - 1 (NeFRC)	Energy from Newfoundland's forest biomass
P - 2 (NeFRC)	Fuelwood consumption in Newfoundland
P - 4 (MFRC)	Tree biomass equations for ten major species in Cumberland County, Nova Scotia
P - 6 (LFRC)	Volume of wood residues for energy production at Parent, Quebec
P - 8 (PNFI)	Tabular summary of data from the literature on the biogeochemistry of temperate forest ecosystems
P - 9 (PNFI)	Forest utilization for energy and the role of nitrogen fixation: a literature review
P - 10 (PNFI)	Intensive culture of green ash and Japanese larch plantations to maximize biomass production
P - 11 (PNFI)	Study to develop a master plan for public awareness of forest biomass as a source of energy
P - 14 (PNFI)	Direct assessment of forest biomass with a radar altimeter
P - 15 (CFS HQ)	Updating of publications of literature reviews concerning forest biomass

* Full establishment names are given in Appendix 2.

Project No. (Responsible Establishment)	Subject
P - 16 (PNFI)	Biomass growth and yield prediction
P - 19 (PNFI)	Cost estimates of forest biomass delivered at the energy conversion plant
P - 20 (PNFI)	Data collection for mature softwood biomass conversion factors
P - 21 (GLFRC)	Biomass inventory of tolerant hardwoods in Algoma, Ontario
P - 22 (NoFRC)	Biomass productivity of young aspen stands in western Canada
P - 23 (NoFRC)	Downed-dead wood estimates in Alberta forest cover types
P - 25 (PFRC)	Energy from forest biomass on Vancouver Island
P - 27 (GLFRC)	Development of a brush harvester
P - 28.1* (CFS HQ/FERIC)	Field tests to develop energy-saving wood comminution techniques
P - 28.2 (CFS HQ/FERIC)	Logging residue survey and the line transect method: a comparison of field and photo methods
P - 28.3 (CFS HQ/FERIC)	Inventory of residues after wood harvesting
P - 28.4 (CFS HQ/FERIC)	Inventory of residual forest biomass after harvesting in western Canada
P - 28.5 (CFS HQ/FERIC)	A review of energy requirements to comminute woody biomass

* "Project P-28" refers to a series of projects completed at the Forest Engineering Research Institute of Canada. For ease of reference, P - 28 has been subdivided into components P - 28.1, P - 28.2, etc.

Project No. (Responsible Establishment	Subject
P - 28.6 (CFS HQ/FERIC)	Forest biomass in Sweden
P - 28.7 (CFS HQ/FERIC)	Building and testing of a prototype for the recovery and processing of logging residues on the ground
P - 28.8 (CFS HQ/FERIC)	Comparative analysis with reference to productivity and energy requirements of two logging residue recovery operations
P - 28.9 (CFS HQ/FERIC)	Trial to comminute log sort debris to fuel stock with a fling demolisher
P - 28.10 (CFS HQ/FERIC)	Survey of logging operations in eastern Canada by major logging system
P - 28.11 (CFS HQ/FERIC)	Methodology for the analysis of the feasibility of recovery of wood residue
P - 28.12 (CFS HQ/FERIC)	Field trials with equipment suitable for the recovery of logging residues
P - 30 (PNFI)	Native poplars and white birch as an unexploited biomass source in Ontario
P - 36 (PFRC)	Development and testing of a field treatment system for logging residues
P - 38 (MFRC)	Biomass inventory of a selected area of mixedwood tolerant hardwood forest in central New Brunswick
P - 39 (MFRC)	Biomass harvesting and chipping in a tolerant hardwood stand in central New Brunswick
P - 40 (MFRC)	Effects of harvesting biomass for energy on the nutrient status and long-term productivity of forest sites
P - 41 (MFRC)	Rate of growth of biomass in young, naturally regenerated stands of different species and origins

Project No. (Responsible Establishment)	Subject
P - 51 (NoFRC)	Upper limits of standing crop density for woody species in the Prairie Provinces
P - 54 (LFRC)	Implications of full-tree harvesting for biomass recovery
P - 59 (PNFI)	Energy analysis of energy from the forest options
P - 64 (PNFI)	A proposal to develop a comprehensive forest biomass growth model
P - 66 (PNFI)	Operational computerized direct data entry technology for collection and analysis of biophysical and biomass data
P - 67 (GLFRC)	Planting machine for mini-rotation poplar
P - 71 (PNFI)	Field research and computer simulation modelling of the long-term consequences of intensive biomass fertility and biomass production
P - 75 (PNFI)	Intensive culture of plantations to maximize biomass production
P - 78 (PNFI)	Uses of nitrogen fixation and other root symbioses for biomass production
P - 92 (NoFRC)	Biomass equations for ten major tree species of the Prairie Provinces
P - 95 (LFRC)	Evaluation of potential impacts of forest biomass harvesting
P - 102 (NoFRC)	An improved stand growth model for trembling aspen in the Prairie Provinces of Canada
P - 112 (NeFRC)	Biomass equations for six tree species in central Newfoundland
P - 115 (NeFRC)	Whole-tree chipping for hogged fuel in Newfoundland

Project No. (Responsible Establishment)	Subject
P - 121 (PNFI)	Effects of spacing and NK fertilizers on dry matter accumulation and nutrient contents of two-year-old Populus x euramericana cv. I-45/51 and cv. robusta DN 17
P - 135 (PFRC)	Forest biomass energy in British Columbia: opportunities, impacts and constraints
P - 138 (PNFI)	Macronutrient content of deciduous tree and shrub samples from the Great Lakes - St. Lawrence Forest Region
P - 139 (PNFI)	Update of Canadian activities in poplar biomass production and utilization
P - 140 (CFS HQ)	Forest biomass inventory system
P - 141 (PFRC)	Development of biomass prediction equations for Yukon tree species
P - 142 (PFRC)	Development of system to estimate quantity of biomass following logging in British Columbia forests to specified recovery criteria
P - 143 (NeFRC)	Integrated logging for production of pulpwood and hog fuel
P - 144 (PNFI)	Manual of data collection and processing for the development of forest biomass relationships
P - 145 (NeFRC)	Reforestation of areas harvested for biomass
P - 146 (NeFRC)	Forest biomass inventory of Newfoundland
P - 148 (NoFRC)	Development and pilot-scale demonstration of an integrated information and mapping capability for forest biomass inventories in the Prairie Provinces and Northwest Territories

Project No. (Responsible Establishment)	Subject
P - 149 (NoFRC)	Impact of climate variation on boreal forest biomass through the use of tree ring analysis
P - 150 (NoFRC)	Extensive literature survey of the growth, yield, and biomass of different tree species and other vegetation present in the boreal zone
P - 152 (GLFRC)	Biomass production from the harvesting of a tolerant hardwood stand in Algoma, Ontario
P - 154 (LFRC)	Hardwood coppice silviculture
P - 155 (LFRC)	Postcut impacts in hardwood stands
P - 157 (LFRC)	Prospects for the use of forest biomass in Quebec
P - 158 (MFRC)	Biomass prediction equations for young red pine plantations in the Maritime lowlands ecosystem
P - 159 (MFRC)	Field sampling to establish a data base for regional biomass prediction equations
P - 162 (PFRC)	Analysis of salvage yarding systems and costs in Pacific Coast forests
P - 163 (NoFRC)	Costs of harvesting aspen stands for energy production
P - 164 (CWS)	Impact on wildlife of short-rotation management of boreal aspen stands
P - 169 (NoFRC)	Development of biomass prediction equations and inventory guidelines for six tree species in the Northwest Territories
P - 170 (CWS)	Evaluation of potential interactions between forest biomass production and wildlife

Project No. (Responsible Establishment)	Subject
P - 172 (NeFRC)	Salix (willow) for biomass fuel and energy conservation
P - 179 (PNFI)	Data collection for developing stand and single tree biomass functions for naturally grown eastern white pine, red pine, eastern white cedar, eastern red cedar, and tamarack in Ontario
P - 182 (GLFRC)	Preparation of a report on ENFOR Project P - 21
P - 183 (PFRC)	Further development of logging residue processing systems
P - 184 (PFRC)	Evaluation of net biomass harvesting and processing costs when sites rehabilitation is considered a benefit
P - 186 (MFRC)	Development of tables to estimate green and dry weight for various species
P - 189 (MFRC)	The economics of harvesting fuelwood under four different stand conditions on Prince Edward Island
P - 190 (NeFRC)	Tree weight equations for Newfoundland
P - 191 (NeFRC)	Harvesting forest biomass as an alternative fuel
P - 193 (LFRC)	Regeneration assessment following complete tree harvesting
P - 194 (LFRC)	Alnus for energy production
P - 197 (PNFI)	Computer modelling of intensive biomass management impacts
P - 198 (PNFI)	Maintaining soil fertility through nitrogen fixing and mycorrhizal symbioses (See also P - 78)

Project No. (Responsible Establishment)	Subject
P - 199 (PNFI)	Impact of harvesting immature trees by the whole-tree method on the microbiology, organic matter contents, and nitrogen transformation of a forest soil
P - 201 (GLFRC)	Design and fabrication of a bundle-tying device for the mini-rotation harvester
P - 203 (CWS)	Impact on wildlife of short-rotation management in boreal aspen stands (See also P - 164)
P - 205 (NoFRC)	Determination of biomass and nutrient content in trees, ground, vegetation and soil of aspen stands in the prairie provinces
P - 207 (NoFRC)	Development of an integrated harvesting and processing system for hardwood sawmilling and energy production
P - 210 (GLFRC)	Development of the Recufor logging residue processor
P - 211 (GLFRC)	Preparation of report on ENFOR Project P - 152
P - 215 (GLFRC)	Application of the Recufor rotor to comminution of residues at landings and processing plants
P - 216 (GLFRC)	Development of a roll splitter
P - 219 (CFS HQ)	Survey of biomass estimation projects
P - 223 (GLFRC)	Development of a mechanized brush harvester
P - 224 (CFS HQ)	Availability and cost of forest biomass in Canada

Project No. (Responsible Establishment)	Subject
P - 225 (LFRC)	Development of black spruce biomass equations for Quebec
P - 226 (CWS)	Impact of forest biomass production on reptiles and amphibians in the Great Lakes-St. Lawrence Forest Region
P - 227 (FSSB)	Coordination of ENFOR biomass estimation projects, and development of biomass estimates based on provincial timber inventories
P - 228 (GLFRC)	Feasibility study on the conversion of an oil/gas heating plant at CFB Borden to a biomass fuel plant
P - 231 (GLFRC)	Development of a mechanized brush harvester
P - 232 (PNFI)	Transfer of nitrogen fixing ability from alder to birch
P - 233 (PNFI)	Energy plantations and soil nutrients levels
P - 234 (PNFI)	Stem measurement and mass data collection for fifteen native hardwood species in Ontario
P - 236 (LFRC)	Biomass equations for Quebec
P - 237 (LFRC)	Equipment test and simulation model for harvesting small woodlots
P - 238 (MFRC)	Trial conversion of conventional inventory data to biomass data
P - 240 (NeFRC)	Avalon biomass inventory pilot trial
P - 242 (FSSB)	Pilot study for the Canada Biomass Inventory
P - 243 (CFS HQ)	Optimization of Recufor rotor

Project No. (Responsible Establishment)	Subject
P - 245 (CFS HQ)	Review and synthesis of ENFOR accomplishments
P - 246 (PFRC)	Biomass equations for Yukon species
P - 247 (MFRC)	Biomass inventory for Nova Scotia: a pilot study
P - 248 (CFS HQ)	Application of sludge to hybrid poplar plantations

APPENDIX 2

Major Organizations Participating in ENFOR Production Program

Major Organizations Participating in ENFOR Production Program

Regional CFS Establishments:

Establishment	Acronym	Contact
Newfoundland Forest Research Centre Building 304, Pleasantville St. John's, Newfoundland A1C 5X8	NeFRC	Mr. R.S. van Nostrand (709) 772-4806
Maritimes Forest Research Centre P.O. Box 4000, College Hill Fredericton, New Brunswick E3B 5P7	MFRC	Mr. G.D. van Raalte (506) 452-3500
Laurentian Forest Research Centre P.O. Box 3800, 1080 Route du Vallon Ste. Foy, Quebec G1V 4C7	LFRC	Dr. G. Frisque (418) 653-2143
Great Lakes Forest Research Centre P.O. Box 490, 1219 Queen St. East Sault Ste. Marie, Ontario P6A 5M7	GLFRC	Mr. B.J. Sutherland (705) 949-9461
Northern Forest Research Centre 5320 - 122nd Street Edmonton, Alberta T6H 3S5	NoFRC	Dr. J.M. Powell (403) 435-7210
Pacific Forest Research Centre 506 West Burnside Road Victoria, British Columbia V8Z 1M5	PFRC	Dr. G.H. Manning (604) 388-3811

Other Organizations:

Establishment	Acronym	Contact
ENFOR Secretariat Canadian Forestry Service Environment Canada Place Vincent Massey 351 St. Joseph Boulevard Hull, Quebec K1A 1G5	ENFOR	Mr. M. Lockman (819) 997-3409
Canadian Forestry Service Headquarters 19th Floor, Place Vincent Massey 351 St. Joseph Boulevard Hull, Quebec K1A 1G5	CFS HQ	Dr. R.C. Dobbs (819) 997-1878
Canadian Wildlife Service 1000 - 9942 108th Street Edmonton, Alberta T5K 2J5	CWS	Mr. E.S. Telfer (403) 435-7320
Forest Engineering Research Institute of Canada 143 Place Frontenac Pointe Claire, Quebec H9R 4Z7	FERIC	Mr. Jean Bérard (514) 694-1140
Forestry Statistics and Systems Branch Canadian Forestry Service Chalk River, Ontario K0J 1J0	FSSB	Mr. R.E. Keen (613) 589-2880
Petawawa National Forestry Institute Canadian Forestry Service Chalk River, Ontario K0J 1J0	PNFI	Dr. L. Chatarpaul (613) 589-2880

APPENDIX 3

Details on ENFOR Projects

VAN NOSTRAND, R.S., 1980. Energy from Newfoundland's forest biomass: a research and development program. Can. Dep. Environ., Can. For. Serv., Nfld. For. Res. Cent., Inf. Rep. N-X-180. 32 p. & append.

ENFOR Project P-1

Comments: Some statistics are now outdated; more accurate estimates have been determined through subsequent projects. It does, however, demonstrate the excellent planning used in structuring the ENFOR Production Program in Newfoundland.

Abstract: The forests of Newfoundland have a potential for making a substantial contribution to the energy needs of the Province. Eight sources of biomass suitable for the production of energy are identified, and quantities estimated. Major sources offering immediate potential are the under-utilized hardwoods which comprise 34 million m^3 of the Island's forests, and the dead and dying softwoods amounting to 22 million m^3 as a result of a severe Island-wide spruce budworm infestation. Estimates of biomass in proximity to the three newsprint mills at Grand Falls, Corner Brook, and Stephenville are given.

The Newfoundland Forest Research Centre is actively involved in the development of the "Energy from the Forest" (ENFOR) Program for the Province. Strategies are outlined in a plan of action which describes completed, ongoing, and proposed projects over the six-year life of the ENFOR Program. Through this Program, an attempt will be made to resolve the more important problems regarding the supply and utilization of forest biomass for energy production. (Author's abstract)

NORTHLAND ASSOCIATES LTD., 1980. Fuelwood consumption in Newfoundland. Can. Dep. Environ., Can. For. Serv., Nfld. For. Res. Cent., Inf. Rep. N-X-177. 43 p. & append.

ENFOR Project P-2

Comments: The survey procedures will be of interest to researchers gathering data on fuelwood consumption.

Abstract: A survey of households was completed in areas of Newfoundland that provided access to wood supplies. Individuals were asked how much wood they burned, when they started burning wood, what type of wood burning unit or other sources of heat they used, their reasons for burning wood, employment, distance travelled to obtain wood, and expected consumption in 1978-79 compared to 1977-78. It was found that the estimated number of households burning wood increased from about 22,000 before 1973 to approximately 32,000 in 1977-78. There was a further estimated increase to about 39,500 in 1978-79. In 1977-78, it was estimated that 461,571 stacked cubic metres of fuelwood were consumed on the Island. This was broken down into 318,916 m^3 of softwood and 142,655 m^3 of hardwood.

Fuelwood consumption accounted for anywhere from 1 percent to 77 percent of the 1977-78 calculated allowable annual cut for the various forest management units on the Island. Overall, fuelwood consumption estimated by the survey accounted for 8 percent of the estimated allowable annual cut. Use of wood as fuel is expected to continue to increase. (Adapted from author's abstract)

KER, M.F., 1980. Tree biomass equations for ten major species in Cumberland County, Nova Scotia. Can. Dep. Environ., Can. For. Serv., Mar. For. Res. Cent., Inf. Rep. M-X-108. 26 p.

ENFOR Project P-4

Comments: This study should be of interest to anyone completing a biomass inventory in eastern Canada because the equations represent well the conditions in these regions. They have been applied in the provincial forest/biomass inventory of Prince Edward Island and close correlation with observations from Newfoundland is reported in Project P-146.

Abstract: Logarithmic equations are given for estimating fresh and dry weights of several tree components for ten common Nova Scotia tree species - balsam fir, white spruce, black spruce, jack pine, red pine, larch, red maple, white birch, aspen and grey (wire) birch. Separate equations are given for each of 12 biomass variables:

1) dry stem wood, 2) dry stem bark, 3) total dry stem, 4) dry branches, 5) dry foliage, 6) total dry crown, 7) total dry tree above-ground, 8) fresh stem wood, 9) fresh stem bark, 10) total fresh stem, 11) total fresh crown, and 12) total fresh tree above-ground. For each of these components the best (i.e. highest R^2) one- and two-variable equations are given. Independent variables tested for predictive ability were DBH, height, crown width and crown length. Stem wood comprised from 62-77% of total dry above-ground weight, stem bark 6-14%, branches 13-19% and foliage 2-11%, based on the mean weights of each component. Average DBH of sample trees ranged from 10.1 cm for grey birch to 17.7 cm for red pine. Average total dry above-ground weights ranged from 38.9 kg for grey birch to 144.1 kg for white birch. Also included in this report is information on percent moisture content, ratios of dry weight to fresh weight for different components, mean weights of each component by species, and softwood branch equations. (Adapted from author's abstract)

BLAIS, MCNEIL, LUSSIER, TREMBLAY ET ASSOCIÉS, ET DENDROTIK INC., 1979. Volume de résidus ligneux pour la production d'énergie à Parent. Can. Dep. Environ., Can. For. Serv., Laur. For. Res. Cent., Inf. Rep. LAU-X-40. 17 p.

ENFOR Project P-6

Comments: A local feasibility study which considers biomass supply but few costs. Statistics on residue quantities may be of interest in conjunction with ENFOR Projects P-28.3 and P-28.4)

Abstract: An average of 57.3 metric tonnes of fresh residues per hectare are found after tree-length logging operations in jack pine stands near Parent, Quebec. This corresponds to 37.2 oven-dry metric tonnes per hectare, consisting of tree tops (38%), broken stems (21%), dead or diseased trees (21%) and branches (19%). Added to this, an average 325 residual stems per hectare are available which represent 6.15 m^3/ha. There also remain 1,901 stumps per hectare with an above-ground volume of 2.03 m^3/ha.

Wood processing in the sawmill in Parent produces, for each m^3 of piled wood in the sawmill's yard, an average of 393.3 kg of chips with a moisture content of 77%, 74.3 kg of bark with a moisture content of 92%, and 20.6 kg of sawdust with a moisture content of 65%.

Available quantities of residues are sufficient to supply a 3 MW thermal plant which would meet the needs of both the sawmill and the town of Parent. (Adapted from authors' abstract)

KIMMINS, J.P., J. DE CATANZARO AND D. BINKLEY, 1979. Tabular summary of data from the literature on the biogeochemistry of temperate forest ecosystems. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 83 p. & bibl.

ENFOR Project P-8

Comments: A useful listing of data sources related to nutrient balance and biomass production.

Abstract: Presents a bibliography of 260 publications together with a series of tables of data from these publications for use with an interactive computer simulation model developed for examining the long-term consequences of intensive forest management and biomass harvest on site nutrient capital and biomass productivity. (Reviewer's abstract)

FORTIN, J. ANDRÉ, ROBERT LAVALLÉE AND YVES PICHÉ, 1979. Forest utilization for energy and the role of nitrogen fixation: a literature review. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 166 p.

ENFOR Project P-9

Comments: Highlights significant issues related to nitrogen fixation and forest biomass production.

Abstract: A literature review of forest biomass production alternatives and related problems is presented, including agroforestry; intensive culture of hybrid poplars, aspens, alders, etc.; and mixed plantations of nitrogen fixers with poplars. The influence of harvesting on soil and its nutrient content is examined. Finally, a research strategy for the use of nitrogen fixation in forest biomass production is presented. (Reviewer's abstract)

INTENSIVE CULTURE OF GREEN ASH AND JAPANESE LARCH PLANTATIONS TO MAXIMIZE BIOMASS PRODUCTION

ENFOR Project P-10; no published report available

Objective: To establish plantations and determine growth rates.

Comments: Plantations have been established and are being maintained. Measurement is planned until 1995. See related work under Projects P-75 and P-233.

STUDY TO DEVELOP A MASTER PLAN FOR PUBLIC AWARENESS OF FOREST BIOMASS AS A SOURCE OF ENERGY

ENFOR Project P-11; no published report available

Objective: See title.

Comments: Proposals are incorporated into the information program at Petawawa National Forestry Institute.

DIRECT ASSESSMENT OF FOREST BIOMASS WITH A RADAR ALTIMETER

ENFOR Project P-14; no published report available

Objective: To test the possibility of using an airborne radar altimeter for direct assessment of biomass.

Comments: Preliminary work is finished. No further work is planned.

WELLWOOD, ROBERT W., 1979, (revision and update of J.L. Keays, 1971). Complete tree utilization: an analysis of the literature (1970-1978). Part I: Biomass of forest tree components. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 89 p.

ENFOR Project P-15

Comments: One of three parts of a major literature review carried out under this project.

Abstract: A literature review on the amounts of biomass in tree components, noting the factors affecting variations within and between species, and indicating the range of harvest gains possible. Average percentages of total biomass contributed by the various components are presented. (Reviewer's abstract)

WELLWOOD, ROBERT W., 1979, (revision and update of J.L. Keays, 1971). Complete tree utilization: an analysis of the literature (1970-1978). Part II: Recovery of biomass. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 150 p.

ENFOR Project P-15

Comments: One of three parts of a major literature review carried out under this project.

Abstract: A review of literature examining total biomass available and that of individual tree components. Studies to determine additional supplies available from unconventional sources in Scandinavian countries are highlighted along with more general studies in North America. Systems for harvesting non-conventional biomass, debarking, comminution, separation, transportation and storage are reviewed. Some environmental and economic considerations are summarized. (Reviewer's abstract)

WELLWOOD, ROBERT W., 1980, (revision and update of J.L. Keays, 1971). Complete tree utilization: an analysis of the literature (1970-1978). Part III: Utilization of biomass. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 170 p.

ENFOR Project P-15

Comments: One of three parts of a major literature review carried out under this project.

Abstract: A literature review encompassing the biomass characteristics of tree components including wood/bark relationships, density, moisture content, fibre morphology, chemical composition, and abnormal wood components. The applicability of component chips for pulp and paper, fibreboards, particle boards, chemical feed stock, and energy is also reviewed. An analysis of economic factors influencing biomass use is presented. (Reviewer's abstract)

BICKERSTAFF, A., W.L. WALLACE AND F. EVERT, 1981. Growth of forests in Canada. Part 2: A quantitative description of the land base and the mean annual increment. Can. Dep. Environ., Can. For. Serv., Petawawa Nat. For. Inst., Inf. Rep. PI-X-1. 127 p. & append.

ENFOR Project P-16

Comments: This is the best available summary of information on the growth rates of Canadian forests. Much of this project was carried out outside ENFOR and important background information has been published by the Canadian Forestry Service in 1977 as Forest Management Institute Information Report FMR-X-98.

Abstract: Bench-mark data on the per hectare productivity and its areal distribution are provided for 139 eco-political units formed by combining the ecologically defined Forest Regions and component Sections of Canada with its politically defined ten provinces and two territories. This relatively stable data base can be grouped as required for changing technical, economic, and political purposes, and is summarized herein at the national, provincial and Forest Region levels of integration.

The mean annual increment to maturity for natural stands of average actual stocking is used to indicate the growth capacity of productive forest land, or, the long-term level of production that can be sustained by basic forest management requiring only satisfactory regeneration, protection, and harvest near rotation age.

For each eco-political unit the following are tabulated: operability class, economic availability, areas of productive forest land, wildland, and improved land. For productive forest land, the relative distribution of forest types, species composition, and site quality is also estimated.

Estimates of growth are compared and discussed in relation to other available national and international data, and with current levels of allowable cut and actual depletion by provinces and species in Canada. (Adapted from authors' abstract)

WIKSTEN, N.A. and P.G. PRINS, 1980. Cost estimates of forest biomass delivered at the energy conversion plant. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 62 p. & append.

ENFOR Project P-19

Comments: Hypothetical cost estimates suggest the least expensive means of harvesting in different conditions.

Abstract: Hypothetical cost estimates, based on 1978 rates and use of conventional logging equipment, are developed for the harvest and delivery of forest biomass from natural stands previously harvested for sawlogs and pulpwood, and for low grade hardwood stands harvested primarily for biomass. Logging waste data from northwestern Ontario were used for the former, while timber cruise data for Great Lakes - St. Lawrence stands were used for the latter.

Use of a forwarder for residue retrieval, with or without manual bunching, was estimated to be more productive and less costly than skidder retrieval. Feller-skidder operations yielded lowest cost estimates for retrieving large residual trees on previously logged areas or for harvesting low grade hardwood stands. (Reviewer's abstract)

DATA COLLECTION FOR MATURE SOFTWOOD BIOMASS CONVERSION FACTORS

ENFOR Project P-20; no published report available

Objective: To develop biomass equations for Ontario softwoods.

Comments: This project is closely tied to P-179 and related to P-234. Some results have been published by Dr. I.S. Alemdag in the "Forestry Chronicle" (February 1982). A comprehensive ENFOR publication is in preparation at the Petawawa National Forestry Institute.

THOMAS, J.B., 1981. Biomass inventory of tolerant hardwoods in Algoma, Ontario. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 25 p. & append.

ENFOR Project P-21

Comments: May be useful in planning the utilization of high-graded tolerant hardwood stands in Ontario.

Abstract: This report summarizes the results of two related studies, one covering the field work for a biomass inventory of 4,738 ha of over-mature tolerant hardwoods, the other for compiling the biomass inventory and relating it on a stand by stand basis with the cubic foot volume inventory of the same area. The first contract required the development of weight/diameter data for hard maple (Acer saccharum Marsh.), yellow birch (Betula alleghaniensis Britton), seven other hardwoods and six coniferous species. Non-linear regression equations were derived and tables of weights for green and dry weights of trees ranging from 2.6 to 100 cm DBH were calculated by components. For the two major species, hard maple and yellow birch, weight/diameter equations were developed for total trees and for stem wood, stem bark, stem total, branches greater than 2 cm in diameter, branches less than 2 cm in diameter, foliage, stump wood, stump bark, roots greater than 2 cm in diameter, roots less than 2 cm in diameter, and for various sub-totals of these components. For the other less important hardwood species, and for the coniferous species, weight/diameter equations were developed for the above-ground components only. Weights of shrubs and saplings less than 1.26 cm were calculated also in two groups, hardwoods and softwoods. On the basis of point sampling, stand tables were prepared for each of the 83 stands in the study area.

In the second contract, the stand tables were combined with the weight/diameter tables to produce biomass estimates, by components, for each stand. These estimates were compared with cubic foot volume estimates for the same stands, to determine the degree of relationship between a biomass inventory and a conventional volume inventory of the same area. (Author's abstract)

BELLA, I.E. AND J.P. DE FRANCESCHI, 1980. Biomass productivity of young aspen stands in western Canada. Can. Dep. Environ., Can. For. Serv., Nor. For. Res. Cent., Inf. Rep. NOR-X-219. 21 p. & append.

ENFOR Project P-22

Comments: Good scientific study which will be useful in predicting biomass yield from natural and plantation aspen stands in the Prairies. Note that Project P-102 covers a similar topic.

Abstract: Equations and tables are presented for estimating above-ground tree component dry weights for fully stocked aspen (Populus tremuloides Michx.) stands up to 40 years old growing on different sites in the mixedwood forests of Alberta and Saskatchewan. The distribution of biomass components in relation to stand age was analyzed, which indicated that with increasing age, the proportion of leaves declines while the proportion of stem wood increases. Optimum rotation lengths were calculated based on culmination of biomass mean annual increment (MAI). Optimum rotation was around 30 years for all conditions, but the estimated maximum total above-ground biomass MAI ranged from 4.8 $t.ha^{-1}$ on better sites (site index 24 m at 50 years) to 2.2 $t.ha^{-1}$ on poorer sites (site index 16 m). (Authors' abstract)

QUINTILIO, D., 1981. Downed-dead wood estimates in Alberta forest cover types. Can. Dep. Environ., Can. For. Serv., Nor. For. Res. Cent., Draft Rep. 19 p.

ENFOR Project P-23

Comments: The results may be of interest to scientists concerned with determining forest fire danger. The findings also confirm that dead and fallen material is an unimportant source of biomass under normal forest conditions.

Abstract: Dead wood material was sampled in 41 coniferous forest cover types in central Alberta. Van Wagner's line intersect sampling method was used. Decomposition classes were assigned to each piece sampled. The average amount of dead downed material for all cover types was 6.71 t/ha; individual stand values ranged from 19.954 t/ha to 0.639 t/ha. Material with a diameter of less than 10 cm accounted for 14% of total weight averaged over all cover types. The averaged state of decomposition was found to be 23% sound, 40% partially decomposed, and 37% "punky". Stand history and fire history were the major factors influencing the weight of dead downed material. The potential of dead downed wood as a commercially viable source of energy is doubtful. (Reviewer's abstract)

PAUL H. JONES AND ASSOCIATES LTD., 1979. Energy from forest biomass on Vancouver Island. Can. Dep. Environ., Can. For. Serv., Pac.,For. Res. Cent., Inf. Rep., BC-X-197. 42 p. & append.

ENFOR Project P-25

Comments: Background material for economic studies and ENFOR program development.

Abstract: A study was performed on Vancouver Island to determine the availability and cost of forest biomass for energy production. Total annual availability of logging slash, red alder and material from precommercial thinnings is 195 million cubic feet. Cost of removal ranged from a high of $73.50/cunit to a low of $25.10/cunit. Within the economic road hauling distance of 30-40 miles, 4 generation sites were identified: Port McNeill/Beaver Cove, Campbell River/Menzies Bay, Lake Cowichan and Port Alberni. Wood costs at these locations would give a fuel cost of about 20 mills/KWH. (Author's abstract)

DEVELOPMENT OF A BRUSH HARVESTER

ENFOR Project P-27; no published report available

Objective: To identify the most appropriate brush harvesting concept and, once identified, to acquire fabrication rights and build the harvester in order to test its operational and economic suitability in typical Canadian conditions.

Comments: See also Projects P-223 and P-231.

JONES, KEITH C., 1981. Field tests to develop energy saving wood comminution techniques. For. Eng. Res. Inst. of Can., Sp. Rep. SR-15. 20 p. & append.

ENFOR Project P-28.1

Comments: Constructive conceptual study of alternative methods of biomass comminution.

Abstract: Energy consumption data of various non-conventional wood comminution machinery were compiled. Energy consumption can be reduced by the following procedures: 1) Development of an infeed mechanism able to accept any material in virtually any orientation, 2) Selection of a comminution mechanism that produces a surface area parallel of the grain rather than perpendicular to it, 3) Production of a particle suitable for compaction and baling in order to increase uniformity and bulk density for transportation and secondary comminution or drying processes. (Reviewer's abstract)

DENDRON RESOURCE SURVEYS LTD., 1981. Logging residue survey and the line transect method: a comparison of field and photo methods. For. Eng. Res. Inst. Can., Sp. Rep. SR-16. 17 p. & append.

ENFOR Project P-28.2

Comments: Demonstrates the practicality of low level large-scale photography inventory methods for logging residue inventory.

Abstract: The volume of logging residue calculated from photogrammetric and ground measurements were compared to assess the reliability of low level 70 mm photography for residue inventory. Errors of photo interpretation omission proved significant for small material less than 5 cm in diameter, but approximate correction factors can be compiled. For material larger than 5 cm, the photo inventory yielded results quite consistently lower than field measurements for individual transects and only 5% lower for the total volume estimate.

The technique offers advantages for inventory of unlayered fresh logging slash in clear cut areas where few standing trees or high shrubs remain. (Reviewer's abstract)

BÉLANGER, JACQUES, JEAN-MARIE DUMONT AND MICHEL LAVERDIÈRE, undated. Inventaire de la biomasse forestière résiduelle après coupe. For. Eng. Res. Inst. of Can., Sp. Rep. RS-13. 136 p. & append.

ENFOR Project P-28.3

Comments: This study indicates the amount of residue left following typical logging operations in New Brunswick, Quebec and Ontario. This work is closely related to ENFOR Project P-28.4.

Abstract: Estimates of the quantities of residual forest biomass are provided for typical harvesting operations. The harvesting systems considered are tree-length logging, full tree logging and shortwood logging. The following cover types are sampled: black spruce (Quebec), jack pine (Ontario), sugar maple (Quebec), and balsam fir (New Brunswick). Sampling methods and precision are described. (Reviewer's abstract)

BÉLANGER, JACQUES, JEAN-MARIE DUMONT AND GERVAIS BÉLANGER, 1981. Inventaire de la biomasse forestière résiduelle après coupe dans l'ouest canadien. For. Eng. Res. Inst. of Can., Sp. Rep. RS-17. 57 p. & append.

ENFOR Project P-28.4

Comments: The range of sampled conditions is small, but the residue quantities observed are probably characteristic of efficient tree-length logging operations in Alberta. This report is closely connected to FERIC Special Report RS-13 (ENFOR Project P-28.3).

Abstract: A survey of logging residues was carried out for a recently harvested lodgepole pine and white spruce stand near Hinton Alberta. Circular 0.04 ha sample plots and line transects were established. The green and oven-dry weight of residue on the area was estimated and classified according to tree components involved.

The line transect method was compared with the use of circular plots. Doubts were expressed about the efficiency of the line transect method, especially in locations with large quantities of residue. (Reviewer's abstract)

JONES, KEITH C., 1981. A review of energy requirements to comminute woody biomass. For. Eng. Res. Inst. of Can., Sp. Rep. SR-14. 38 p. & append.

ENFOR Project P-28.5

Comments: This is a good description of the principles and equipment for reducing biomass to small particles by chipping, rolling, crushing and other processes. This report is background material for the research described in Special Report SR-15, ENFOR Project P-28.1.

Abstract: This report compares in graphical and tabular form the energy required to comminute wood material to nominal sizes using chippers, hammermills, brush flails, roll crushers, and baling mechanisms. The energy requirements to produce surface areas perpendicular and parallel to the grain are also compared. (Author's abstract)

WIKSTEN, N.A., 1980. Forest biomass in Sweden. For. Eng. Res. Inst. of Can., Contractor's Report. 24 p.

ENFOR Project P-28.6

Comments: Of interest when written; now dated.

Abstract: The role of forest biomass in Sweden's energy situation in 1979 is described and relevant public and private sector programs are discussed. Activities at the Logging Research Foundation are described in some detail. (Reviewer's abstract)

BUILDING AND TESTING OF A PROTOTYPE FOR THE RECOVERY AND PROCESSING OF LOGGING RESIDUES ON THE GROUND

ENFOR Project P-28.7; no published report available

Objective: To build and test a prototype of a residue harvesting machine. Only the main processing component is involved. It consists of a powered drum with curved teeth rotating counter clockwise and mounted on a steel carrier.

Comments: Completed, early work which led to the Recufor harvester. For related work, see Projects P-28.8, P-210 and P-215.

COMPARATIVE ANALYSIS WITH REFERENCE TO PRODUCTIVITY AND ENERGY REQUIREMENTS OF TWO LOGGING RESIDUE RECOVERY OPERATIONS

ENFOR Project P-28.8; no published report available

Objective: Data are collected on one and two pass full-tree harvesting operations for a comparative analysis. Tests are conducted in three forest types: 1) mixedwood with dominant hardwood (poplar, white birch), 2) mixedwood with dominant softwood (spruce, fir, jack pine), and 3) mixedwood with equal proportions of softwood and hardwood.

Comments: This project is related to Recufor development studies P-28.7, P-210 and P-215.

TRIAL TO COMMINUTE LOG-SORT YARD DEBRIS TO FUEL STOCK WITH A FLING DEMOLISHER

ENFOR Project P-28.9; no published report available

Objective: An operational trial to determine operating costs, energy requirements, and efficiency of the Fling Demolisher for sorting and processing log sort yard debris. Also, an assessment of the remainder of the fuel stock refining system, including handling and transportation, hog milling, and burning of processed debris will be carried out.

Comments: Under development through Western Division of FERIC.

P-28.10

SURVEY OF LOGGING OPERATIONS IN EASTERN CANADA BY MAJOR LOGGING SYSTEM

ENFOR Project P-28.10; no published report available

Objective: To survey logging operations in Ontario, Quebec, New Brunswick, and Nova Scotia by major harvesting system.

Comments: See Project P-28.3 for related work.

METHODOLOGY FOR THE ANALYSIS OF THE FEASIBILITY OF RECOVERY OF WOOD RESIDUE

ENFOR Project P-28.11; no published report available

Objective: To develop methodology for the analysis of the feasibility of wood residue recovery.

Comments: This is an abandoned project proposal. See related work elsewhere under P-28.

FIELD TRIALS WITH EQUIPMENT FOR THE RECOVERY OF LOGGING RESIDUES

ENFOR Project P-28.12; no published report available

Objective: To design and propose a methodology to conduct field trials with equipment suitable for the recovery of logging residues.

Comments: This project was terminated in the early stages.

HORTON, K.W., 1981. Biomass yield tables for aspen in Ontario. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 9 p. & tables.

ENFOR Project P-30.1

Comments: The report outlines procedures used to develop yield tables.

Abstract: Biomass growth and yield tables are presented for fully-stocked aspen (Populus tremuloides Michx.) stands up to 90 years old in two forest regions of Ontario – the Boreal and the Great Lakes - St. Lawrence. Whole-tree biomass maximum mean annual increments range from 2.2 to 4.7 oven-dry tonnes per hectare per year, forming a plateau between ages 40 to 70 in the Boreal and 30 to 60 in the Great Lakes Region. Recommended biomass rotation ages are 40 and 30 respectively. Yields in the Boreal Region exceed those in the Great Lakes Region by from 18 to ca. 30%. Stemwood oven-dry mass constitutes 68-72% of above-ground, whole-tree mass. Only 3% is found in twigs and leaves. (Adapted from author's abstract)

HORTON, K.W., 1981. Biomass potential of aspen and white birch in Ontario. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 33 p.

ENFOR Project P-30.2

Comments: This is an interesting literature review that attempts to translate the scientific literature into pragmatic estimates of aspen biomass potential.

Abstract: Over 12 million hectares of Ontario's productive forests contain aspen,poplar and white birch in pure stands or mixed with conifers, and less than 10% of the annual allowable cut has been utilized. On the basis of biomass equations and yield tables developed in these studies, it is estimated that the annual growth of aspen and birch could supply up to 16% of the province's primary energy needs. Heavy concentrations are located in certain boreal districts where biomass plants could be supplied in conjunction with established plywood, waferboard and pulp-mill operations. The harnessing of biomass from aspen in particular, which grows much faster than major associated species and regenerates abundantly by root suckering, would incidentally solve pressing forest management concerns and greatly increase forest productivity as a whole. Silvicultural and management options for maximizing the potential are described.

Biomass regression equations are presented for aspen and white birch. A generalized summary of FRI data is presented to show broad estimates of current species distribution with emphasis on aspen and white birch. Aspen biomass energy conversion plants are suggested as potentially feasible for many districts of northern, north-central, and northwestern Ontario. (Adapted from author's abstract)

BLAKENEY, K.J., 1980. Developing and testing of a field treatment system for logging residues. Can. Dep. Environ., Can. For. Serv., Pac. For. Res. Cent., Inf. Rep. BC-X-212. 57 p. & append.

ENFOR Project P-36

Comments: The study provides an excellent evaluation of a residue collecting system. The pilot tests exposed various technical problems associated with the machinery and corrective measures are suggested.

Abstract: Full utilization of the forest resource has long been the goal of resource planners. The aim of this project was to identify and test methods of reaching this goal. Forest residues on two recently logged sites representing a range of residue concentration and type were inventoried and classified. Residues were collected into piles and were processed using two different types of mobile chippers. Samples of the processed material were analyzed to determine their physical and energy properties. A portion of the chipped material was transported to a hog fuel boiler for burning.

Each phase of the work was monitored to determine productivity, cost and fuel consumption. Results show the cost per tonne for each phase of the operation and the ratio of energy consumed to energy produced. (Author's abstract)

BIOMASS INVENTORY OF A SELECTED AREA OF MIXEDWOOD/TOLERANT HARDWOOD FOREST IN CENTRAL NEW BRUNSWICK

ENFOR Project P-38; no published report available

Objective: A 100% inventory of above ground biomass in a selected 8 ha block of mixedwood/tolerant hardwood forest in central New Brunswick was carried out. Biomass equations were developed concurrently for the major species. Inventory techniques identical to those in Project P-4 were used. Equation accuracy was tested after a pilot harvesting trial (P-39) by re-inventorying the cutover block for biomass quantity.

Comments: The report for this project is in preparation.

CHRISHOLM, B.S. AND G.D. VAN RAALTE, 1980. Biomass harvesting and chipping in a tolerant hardwood stand in central New Brunswick. Can. Dep. Environ., Can. For. Serv., Mar. For. Res. Cent., Inf. Rep. M-X-111. 9 p.

ENFOR Project P-39

Comments: A practical demonstration of conventional whole tree harvesting and chipping at reasonable cost.

Abstract: Four 2 ha blocks were harvested after the completion of a total biomass inventory. Three blocks were harvested by the Koehring Feller-Forwarder and chipped by a Model 22 Morbark Chiparvester, while the remaining block was cut using conventional cut and skid techniques to produce 2.5 m roundwood. The productivity and costs of harvesting each block were measured accurately. On two blocks the costs of harvesting the residual biomass after completion of the normal harvest were also determined. The feasibility and economics of harvesting this residual biomass are briefly discussed.

Stands, particularly hardwoods, that are now marginally operable by chain saw and skidder can be harvested for pulp fibre or feed stock for fuel by KFF or similar whole tree harvesting techniques, at acceptable cost and with a significant increase in total fibre yield. (Adapted from authors' abstract)

FREEDMAN, B., 1981. Intensive forest harvest: a review of nutrient budget considerations. Can. Dep. Environ., Can. For. Serv., Mar. For. Res. Cent., Inf. Rep. M-X-121, 35 p. & tables.

ENFOR Project P-40.1

Comments: Well organized tabular presentation of data extracted from literature on forest nutrients, their natural accumulation and depletion by harvesting.

Abstract: Presents discussion of literature and tabulated data on removals, additions and net fluxes of nutrients applicable to northern temperate forests. Simple calculations indicate the relatively rapid impoverishment of the site caused by short-rotation Populus plantations with whole-tree biomass harvest. Medium or longer term rotations would result in more moderate nutrient removals, apparently of less ecological significance. Due to wide variations in many of the data on which calculations were based, results are tentative. (Reviewer's abstract)

FREEDMAN, B., P.N. DUINKER, H. BARCLAY, R. MORASH AND U. PRAGER, 1982. Forest biomass and nutrient studies in central Nova Scotia. Can. Dep. Environ., Can. For. Serv., Mar. For. Res. Cent., Inf. Rep. M-X-134. 11 p. & append.

ENFOR Project: P-40.2

Comments: Nutrient content prediction equations for tree components; will assist in determining the advisable degree of intensity of biomass harvesting.

Abstract: Logarithmic and quadratic equations are given for estimating the fresh and dry weights and nutrient contents (N, P, K, Ca, and Mg) for various components of ten tree species in central Nova Scotia. These species are: balsam fir, white spruce, black spruce, red spruce, red maple, sugar maple, yellow birch, white birch, large-tooth aspen and trembling aspen. The relative distributions of biomass and nutrient content among the various components are described for each species.

Data are presented on the above ground standing crops of biomass and nutrients (N, P, K, Ca, and Mg) in various tree compartments for eight hardwood stands in central Nova Scotia. (Authors' abstract)

RATE OF GROWTH OF BIOMASS IN YOUNG, NATURALLY-REGENERATING STANDS OF DIFFERENT SPECIES AND ORIGINS

ENFOR Project P-41; no published report available

Objective: To estimate the growth rates of young natural stands in New Brunswick and Nova Scotia. The cover types sampled were balsam fir, old field white spruce, alder and hardwood stands which included red maple, sugar maple, white birch and yellow birch.

Comments: A preliminary report describing mathematical models for estimation of biomass quantities has been submitted to the Maritimes Forest Research Centre.

PETERSON, E.B., V.M. LEVSON, AND R.D. KABZEMS, 1982. Upper limits of standing crop density for woody species in the prairie provinces. Can. Dep. Environ., Can. For. Serv., Nor. For. Res. Cent., Inf. Rep. NOR-X-243. 28 p. & append.

ENFOR Project P-51

Comments: Useful information which indicates expected yields and specifications for biomass harvesting equipment.

Abstract: Young tree and shrub stands in Alberta, Saskatchewan, and Manitoba were sampled in 1979 to obtain estimates of maximum standing crop density. Above-ground standing crop values double the regional averages were found, with upper limit dry weights of 16.9 t/ha for a 3 year old aspen-alder stand, 18.1 t/ha for a 4 year old asper-alder stand, and 29.6 t/ha for a 5 year old aspen stand. Some young stands achieved standing crop densities comparable to those of fully closed mature stands. Recorded standing crop densities included 2.16 kg/m^3 for an 8 year old willow stand, 1.66 kg/m^3 for an 8 year old lodgepole pine stand, and 1.19 kg/m^3 for a 9 year old alder stand. Equations for predicting foliage dry weight, wood dry weight, and total above-ground dry weight from independent variables of stem diameter, stem height, stand age, and number of stems per hectare yielded results of low reliability. (Authors' abstract)

ROUTHIER, JEAN-GUY, 1981. Implications de l'exploitation par arbres entiers pour la récupération de la biomasse. Can. Dep. Environ., Can For. Serv., Laur. For. Res. Cent., Inf. Rep. LAU-X-50. 112 p. & append.

ENFOR Project P-54

Comments: This is a practical application of present day technology to the development of a full-tree harvesting system. The single pass operation was designed to produce conventional forest products with the waste being diverted to energy production.

Abstract: If trees are delimbed and topped at a plant site rather than at the cutting area, their limbs and tops can more readily be used for energy production. In the green state, recovered limbs and tops constitute a biomass of 200 to 300 kilograms per cubic metre of merchantable wood for softwood species in Eastern Canada. Full trees can be harvested and transported on private roads without major difficulty. A plant concept for delimbing, topping, slashing and debarking of trees is presented in this report.

The elimination of delimbing in the forest promotes mechanization of felling and skidding operations. If the additional biomass that is recovered can be sold at $35 per oven-dry tonne — a much lower price than the energy equivalent amount of oil ($54) — then the additional investments required in the forest and at the mill to recover the biomass yield an after-tax rate of return at real prices (no inflation) of 27%. Chipping full trees in the forest and purifying the chips at the mill is a process now being developed that offers the pulp and paper industry another means of recovering a maximum amount of biomass. Current knowledge of this technique indicates that its economic potential is comparable to that of processing full trees at a plant. (Author's abstract)

ASH, M.J., P.C. KNOBLOCK AND N. PETERS, 1980. Energy analysis of energy from the forest options. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 79 p. & append.

ENFOR Project P-59

Comments: An interesting treatment of the energy balance in the harvest, transportation and conversion of biomass. Economic feasibility is not considered.

Abstract: Energy analysis was applied to the harvesting, transportation, and conversion of forest residue for energy. A review of European and North American literature and Eastern and Western Canada case studies provided the data base. It was found that energy requirements for harvesting forest residue could be projected from energy consumption data for conventional logging systems. An energy assessment of a theoretical model of a biomass production and conversion system on Vancouver Island was studied. The energy output/input ratio of 6.94 showed that substantial positive net energy would be produced. This result was found to be relatively insensitive to small errors in energy estimates for harvesting and transportation. (Adapted from authors' summary)

SMITH, J. HARRY G. AND D.H. WILLIAMS, 1980. A proposal to develop a comprehensive forest biomass growth model. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 47 p.

ENFOR Project P-64

Comments: The general comments on growth and yield models may be of interest.

Abstract: The state of the art of biomass modelling was reviewed. The need for and objectives of biomass and conventional timber product modelling, data base requirements, and modelling strategies were examined. Conventional stand models adapted to produce biomass predictions were reviewed and two proposals for adapting conventional stand models for determining stand biomass growth were developed. The first alternative would create a comprehensive stand biomass growth model at the highest level of detail. This would require 1.5 to 3 years of professional time, a similar amount of technician-programmer time and about $30,000 of computer time. The less ambitious alternative was designed to firm up ideas and demonstrate the concepts involved. It would require two man-months of professional time, four man-months of technician-programmer time, and about $15,000 of computer time. Both proposals were to use existing conventional stand models as a submodel. (Reviewer's abstract)

OPERATIONAL COMPUTERIZED DIRECT DATA ENTRY TECHNOLOGY FOR COLLECTION AND ANALYSIS OF BIOPHYSICAL AND BIOMASS DATA

ENFOR Project P-66; no published report available

Objective: To develop a system for recording measurements in the field and transmitting them by telephone to a computer.

Comments: Prototype is in operation at Ontario Ministry of Natural Resources, Brockville, Ontario. A report will be prepared after a one-year trial.

PLANTING MACHINE FOR MINI-ROTATION POPLAR

ENFOR Project P-67; no published report available

Objective: To examine existing machines and evaluate their performance in planting poplars. The characteristics of poplar cuttings and the properties of soils were also considered for the design of a new planting machine.

Comments: Project completed with preliminary evaluations. No further work is proposed.

FIELD RESEARCH AND COMPUTER SIMULATION MODELLING OF THE LONG-TERM CONSEQUENCES OF INTENSIVE BIOMASS FERTILITY AND BIOMASS PRODUCTION

ENFOR Project P-71; no published report available

Objective: See title.

Comments: Activities under Project P-71 are part of a project described under P-197.

INTENSIVE CULTURE OF PLANTATIONS TO MAXIMIZE BIOMASS PRODUCTION

ENFOR Project P-75; no published report available

Objective: To establish plantations and determine growth rates.

Comments: Plantations have been established and are being maintained. Measurement is planned until 1995. See related work under Projects P-10 and P-233.

FORTIN, J. ANDRÉ, 1981. Uses of nitrogen fixation and other root symbioses for biomass production. Can. Dep. Environ., Can. For. Serv., Contractor's Progress Report. 25 p. & append.

ENFOR Project P-78

Comments: Results will appear in future reports (see P-198).

Abstract: An early progress report on seedling selection and plantation preparation to study the use of nitrogen-fixing and mycorrhizal symbiosis in intensive forest management to increase biomass production and maintain fertility. Alders, aspens, hybrid poplars, willows, and jack pine seedlings are used. (Reviewer's abstract)

SINGH, T., 1982. Biomass equations for ten major tree species of the Prairie Provinces. Can. Dep. Environ., Can. For. Serv., Nor. For. Res. Cent., Inf. Rep. NOR-X-242. 35 p.

ENFOR Project P-92

Comments: Equations are presented for the conversion of conventional volume inventories to biomass inventories.

Abstract: Based on a sample of 60 trees of each species, prairie regional biomass equations are developed to convert conventional forest inventories to above-ground biomass inventories. Equations are given for jack pine, lodgepole pine, white spruce, black spruce, balsam fir, alpine fir, larch, trembling aspen, balsam poplar and white birch. (Reviewer's abstract)

GROUPE DRYADE, 1980. Evaluation of potential impacts of forest biomass harvesting. Can. Dep. Environ., Can. For. Serv., Laur. For. Res. Cent., Inf. Rep. LAU-X-45E. 50 p.

ENFOR Project P-95

Comments: Useful for the design or review of integrated studies of the environmental impacts of biomass harvesting.

Abstract: A comprehensive approach is developed for designing integrated environmental impact studies of biomass harvesting. Primary impacts of biomass harvesting on climate, water, soil, wildlife and vegetation are outlined from the literature. Secondary impacts are then associated with the primary impacts. Erosion is emphasized as a central causal factor of negative impacts.

Interrelationships between harvesting operations, primary and secondary impacts are analyzed with Leopold's and CNYR matrices. Flow diagrams developed from the latter highlight the interrelationships among principal variables and allow isolation of the most critical ones. (Reviewer's abstract)

DANCIK, BRUCE P., JACK D. HEIDT, KENNETH O. HIGGINBOTHAM AND STEPHEN J. TITUS, 1980. Development of a stand growth model for trembling aspen in the Prairie Provinces of Canada. Can. Dep. Environ., Can. For. Serv., Contractor's Rep. 99 p. & append.

ENFOR Project P-102

Comments: This report includes a review of literature on the growth of aspen and growth models in general. Other work related to this project is described in a subsequent report (Grabowski, Heidt, and Titus, 1981).

Abstract: This project summarizes the first phase of ENFOR Project P-102, "Development of a stand growth model for trembling aspen in the Prairie Provinces of Canada". An extensive literature review is included for growth modelling generally and aspen growth in particular. A preliminary growth model was developed, using a very limited data set, which predicts average stand characteristics given site index, age, number of trees, and a factor specifying clonal productivity. Limitations of this preliminary model are discussed and a proposal is included, for the second phase, to construct a more sensitive model using a more comprehensive data set. (Authors' abstract)

GRABOWSKI, TOM I., JACK D. HEIDT AND STEPHEN J. TITUS, 1981. An improved stand growth model for trembling aspen in the Prairie Provinces of Canada. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 49 p. & append.

ENFOR Project P-102

Comments: The model unit must be tested with independent data before it can be recommended for practical use. The authors recognize that thinning will increase diameter growth, but is unlikely to raise biomass production.

Abstract: This study builds upon preliminary work described by Dancik, Heidt, Higginbotham and Titus (1980). A stand growth model, based on the development of individual trees, is proposed for aspen in the Prairie Provinces. Stem diameter distributions at selected ages are simulated for given sites and densities. Thinning is the only management treatment incorporated into the model. (Reviewer's abstract)

LAVIGNE, M.B., AND R.S. VAN NOSTRAND, 1981. Biomass equations for six tree species in central Newfoundland. Can. Dep. Environ., Can. For. Serv., Nfld. For. Res. Cent., Inf. Rep. N-X-199. 17 p. & append.

ENFOR Project P-112

Comments: Equations and tables are presented in a form that is ready for use in compiling biomass inventories. This study complements several other reports completed under ENFOR Project P-112 and has counterparts in other provinces.

Abstract: Biomass data were collected in central Newfoundland for six major tree species. Biomass tables for oven-dried mass of above-ground components and the whole tree were constructed using regression analyses. Five models for estimating biomass were tested. A weighted regression using D^2H as an independent variable had the best fit and the most satisfactory statistical properties. Adjustments were made to ensure that the total estimated mass of any tree would equal the sum of the estimated masses of its components. (Adapted from authors' abstract)

NORTHLAND ASSOCIATES LTD., 1982. Tree weight equations, data acquisition phase, eastern Newfoundland. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 28 p. & append.

ENFOR Project P-112

Comments: This is one of several reports on P-112. The project has its counterparts in other provinces (e.g. P-4, P-92). See also P-144.

Abstract: The paper summarizes methods used in the data collection phase of a study to develop tree weight tables for the five major species of eastern Newfoundland. Boles, dead branches, large green branches, small green branches, and foliage were sampled separately. (Adapted from author's abstract)

NORTHLAND ASSOCIATES LTD., 1981. Tree weight equations, data acquisition phase, western Newfoundland. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 17 p. & append.

ENFOR Project P-112

Comments: This is one of several reports on P-112. The project has its counterparts in other provinces (e.g. P-4, P-92). See also P-144.

Abstract: The paper summarizes procedures used in the data collection phase of a study to develop tree weight tables for six major tree species of western Newfoundland.

Boles, dead branches, large green branches, small green branches and foliage were sampled separately. (Adapted from author's abstract)

WILTON, W.C. AND W.P. DUFFETT, 1980. Whole tree chipping for hogged fuel in Newfoundland. Can. Dep. Environ., Can. For. Serv., Nfld. For. Res. Cent., Inf. Rep. N-X-186. 46 p. & append.

ENFOR Project P-115

Comments: Good example of operational trail of biomass harvest and conversion for energy production.

Abstract: A three-month whole-tree chipping trial to determine the feasibility of using hogged fuel for steam generation at the Price (Nfld.) Pulp and Paper Ltd. mill was conducted in 1979. Two white birch stands and a burned black spruce-balsam fir stand were harvested. Trees were felled manually, hauled whole-tree to a central landing using wheeled skidders, chipped with a Morbark Model 22 Chiparvester and transported in modified dump trucks to the mill yard. The chips were burned in a boiler furnace designed for bark and/or bunker oil.

Wood from the two birch stands was harvested and burned at savings of 32% and 15% compared to the cost of burning the equivalent amount of oil. The greater saving was achieved from the older of the two stands, where trees were larger resulting in more efficient logging and chipping. In the burned softwood stand, a loss of 30% for wood costs compared to oil is attributed to excessive road-building costs, short period of operation, and small diameter trees resulting in inefficient logging and chipping.

The effects of whole tree removal on the extent of ground disturbance and on regeneration, are similar to that for a normal pulpwood logging operation. On the hardwood sites, birch stump suckers will be a problem if a species change is planned for the future crop. (Authors' abstract)

OGAR, GEORGE E., 1981. Effects of spacing and NK fertilizers on dry matter accumulation and nutrient contents of two-year-old Populus x euramericana cv. 1-45/51 and cv. robusta DN17. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 119 p. & append.

ENFOR Project P-121

Comments: Offers interesting management suggestions for very short rotation biomass plantations.

Abstract: Seasonal nutrient concentrations and contents and dry matter accumulation for Populus x euramericana clone robusta DN17 and Populus x euramericana clone 1-45/51 were studied under field conditions using two-year-old saplings to obtain some basic information for establishing mini-rotation poplar plantations.

Row spacings varying from 0.3 m to 3.0 m in Nelder plots and three levels of fertilizers, N_0K_0, $N_{200}K_{100}$ and $N_{600}K_{300}$ (Kg/ha) were used as treatment factors.

Foliar elemental concentrations were not affected by spacing, but rather by NK fertilizers which significantly increased NPK concentrations and depressed the concentrations of calcium and magnesium. Maximum foliar NPK concentrations occurred in late spring while those of Ca and Mg were in mid-summer.

In a two year rotation, the row spacing of 1.8 m in Nelder plots induced maximum growth response per sapling for the two clones.

Dry matter and nutrient accumulation on an area basis increased with declining spacing distances. In single tree analysis, the opposite trends prevailed.

Clonal differences emerged in the response of the two hybrid poplars to NK fertilizers.

Regressions of dry matter/stem density and nutrient content/dry matter indicate high correlations between the dependent and independent variables. (Adapted from author's abstract)

MCDANIELS, T.L., 1982. Forest biomass energy in British Columbia: opportunities, impacts, and constraints. Can. Dep. Environ., Can. For. Serv., Pac. For. Res. Cent., Inf. Rep. BC-X-226. 151 p. & append.

ENFOR Project P-135

Comments: A comprehensive examination of factors impinging on forest biomass energy use in British Columbia.

Abstract: Vast quantities of forest biomass are available in B.C. as a by-product of conventional forest industries. If alternative conventional energy sources were priced on the basis of their marginal costs, the demand for forest biomass would grow rapidly, particularly within the pulp sector. This sector would account for about 75% of the potential forest energy use and become nearly self-sufficient in energy. Economic priorities for biomass energy uses were estimated to be methanol, hog fuel for pulp boilers, dry kilns, cogeneration and electricity. By 1995, between 735 and 1,180 jobs could be created directly, and twice that number indirectly.

A primary constraint to biomass energy use is the current pricing of electricity and natural gas to industrial users.

Large positive impacts could be expected on the forest industry, the regional economy and the environment. A variety of incentive measures is recommended to eliminate the identified constraints to this expanded use of biomass. (Reviewer's abstract)

MACRONUTRIENT CONTENT OF DECIDUOUS TREE AND SHRUB SAMPLES FROM THE GREAT LAKES - ST. LAWRENCE FOREST REGION

ENFOR Project P-138; no published report available

Objective: An attempt to estimate biomass content with the help of biomass equations.

Comments: Preliminary report is available at Petawawa National Forestry Institute. The results are not encouraging.

ZSUFFA, L., D. BOUFFORD AND M.A. LEGGAT, 1979. Update of Canadian activities in poplar biomass production and utilization. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 62 p. & tables & append.

ENFOR Project P-139

Comments: This is an important review of the 1979 state of knowledge concerning poplars.

Abstract: Based on a survey of specialists and the literature, it is concluded that knowledge of poplar taxonomy, genetics and ecology is very superficial compared to knowledge about most other species. Inventory information on areas and volumes is incomplete and few current projects are generating the required data. The silvicultural and management of poplar stands has been neglected.

The report presents summary tables collating information available by net merchantable province volumes, plantations, nurseries, allowable annual cut, utilization, and current research programs in Canada. (Reviewer's abstract)

DEVELOPMENT OF THE CANADIAN FOREST RESOURCE DATA SYSTEM

ENFOR Project P-140; no published report available

Objective: To develop and implement nationally the Canadian Forest Resource Data System (CFRDS). Work involved the development of a continuous computerized system for accumulating, storing, retrieving, and mapping forest data which are essential for estimating forest biomass resources in Canada.

Comments: Results have been incorporated into an operational system at Forestry Statistics and Systems Branch, Canadian Forestry Service, Chalk River, Ontario.

DEVELOPMENT OF BIOMASS PREDICTION EQUATIONS FOR YUKON TREE SPECIES

ENFOR Project P-141; no published report available

Objective: To collect data for biomass equations and growth studies.

Comments: The data have been collected. Work is continuing under Project P-246.

DEVELOPMENT OF A SYSTEM TO ESTIMATE QUANTITY OF BIOMASS FOLLOWING LOGGING IN BRITISH COLUMBIA FORESTS TO SPECIFIED RECOVERY CRITERIA

ENFOR Project P-142; no published report available

Objective: See title, above.

Comments: The analysis for this project is still being carried out.

WILTON, W.C., 1981. Integrated logging for production of pulpwood and hog fuel. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 38 p. & append.

ENFOR Project P-143

Comments: A continuation of field trials to harvest biomass for hog fuel in conjunction with pulpwood and sawlog operations fraught with unforeseen problems. See also Wilton and Duffet (1980), ENFOR Project P-115.

Abstract: Three trials were carried out to assess the economic feasibility and environmental effects of whole tree biomass harvesting. Two involved retrieval of residual hardwood and some softwood logging debris from cutovers of mixedwood stands. The third trial involved integrated biomass and conventional sawlog and pulpwood harvesting. Salvage of softwood cutting debris in addition to standing timber was economically the least successful. Salvage of hardwood biomass only from mixedwood cutovers resulted in the smallest financial loss. Morbark 22 Chiparvester proved too large for processing pulpwood cutting debris. Salvage of residual biomass did not result in excessive damage to reproduction or to the growing site. (Reviewer's abstract)

ALEMDAG, I.S., 1980. Manual of data collection and processing for the development of forest biomass relationships. Can. Dep. Environ., Can. For. Serv., Petawawa Nat. For. Inst., Inf. Rep. PI-X-4. 6 p. & append.

ENFOR Project P-144

Comments: This manual is significant because the Canadian Forestry Service intended it as a standard to be followed in biomass data collection.

Abstract: This report describes an attempt to develop a standard method of collecting field data and processing them in the laboratory so that relationships may be established between the above ground biomass of standing timber and conventional measurable variables. It is based on the field and laboratory experiences obtained at the Petawawa National Forestry Institute and on the search of the literature on methodologies. Because numerous studies of this nature are being, and will be, conducted for various tree species and forest types, the intent of the report is to reduce conflict to a minimum by encouraging uniformity in approach and in the expression of results.

The proposed data collection procedure is organized in such a way as to provide data on (1) developing single-tree mass functions, (2) constructing mass yield tables, and (3) converting volumetric inventory figures into mass. The manual covers both sample plot and sample tree measurements in the field. However, these two measurements need not be done together: they can be combined or made separately, depending upon the purpose of the work. Furthermore, the methods can be altered to meet local requirements. (Adapted from ENFOR Review, September 1980)

RICHARDSON, J., M.A.K. KHALIL AND J. WINKLER, 1981. Reforestation of areas harvested for biomass in Newfoundland. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 22 p.

ENFOR Project P-145

Comments: An interesting follow-up to biomass harvesting of pure white birch stands to determine alternative management strategies for the future.

Abstract: A first year report of a study on management alternatives for a site recently clearcut for hardwood biomass. Three alternatives are considered: natural hardwood regeneration, planting hybrid poplars, and converting to softwoods.

In the regeneration study, site treatments, including stump pulling and scarification are discussed.

In the poplar study, hardwood control treatments presented include brushsaw cutting and glyphosate application. Selected hybrid poplar clones are used.

The regeneration trials in the forest conversion study are white spruce container seedlings, 2-1 black spruce bare roots seedlings, black spruce container seedlings, larch container seedlings, broadcast seeding of black spruce, and control. Hardwood control treatments include brushsaw cutting, 2,4-D, glyphosate, and brushsaw plus 2,4-D. (Reviewer's abstract)

DENDRON RESOURCE SURVEYS LTD. AND NORTHLAND ASSOCIATES LTD., 1982. Procedures for estimating Newfoundland's biomass reserves. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 27 p. & append.

ENFOR Project P-146

Comments: Includes a clear description of statistical methods employed.

Abstract: Techniques are developed and described for deriving tree weight equations for conversion of Newfoundland's conventional forest inventories to biomass values. Twenty tree weight equations, developed for eastern and boreal forests, were tested with tree component biomass data from Newfoundland. Models were tested for geometric reasonableness, "goodness-of-fit", equality of variance of residuals, cost effectiveness of obtaining field data on additional variables, and consistency of models among species and components. A model including diameter and height was selected. Field tests indicated that the marginal gain in precision from adding crown variables was not worth the cost of collecting data.

The amounts of biomass contained in shrubs and trees in 1 - 9 cm sizes was not important except in dense balsam fir or black spruce stands or in young stands of white birch. Field tests indicated that modificatio of current field procedures for forest inventory by the addition of 3 x 3 m square plots for caliper measurement of trees and shrubs 1.0 to 8.9 cm dbh would provide appropriate biomass data for small material. (Reviewer's abstract)

DEVELOPMENT AND PILOT SCALE DEMONSTRATION OF AN INTEGRATED INFORMATION AND MAPPING SYSTEM FOR FOREST BIOMASS INVENTORIES

ENFOR Project P-148; no published report available

Objective: To develop an interactive information system capable of processing cartographic and biomass inventory data. System design will be compatible with provincial and national data bases. Data base will be used for economic stimulation modelling and to demonstrate the feasibility of using Landsat data for updating conventional forest inventories.

Comments: The system is almost operational and is set up at the Northern Forest Research Centre in Edmonton.

JOZSA, L.A., M.L. PARKER, P.A. BRAMHALL, AND S.G. JOHNSON, 1982. Impact of climatic variation on boreal forest biomass through the use of tree-ring analysis. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 47 p.

ENFOR Project P-149

Comments: An interesting application of new x-ray scanning techniques to develop dendrochronological data to relate growth and climate.

Abstract: Tree-ring samples were collected from living white spruce [Picea glauca (Moench) Voss] from eight sites in Alberta, Northwest Territories and Manitoba along two south to north transects from the southern limit of the boreal forest to the open subarctic forest. The main objective was to study the effect of climatic variability on tree growth through time and space. Computerized x-ray densitometry techniques were used to produce detailed annual ring width and ring density chronologies. Ring width, ring density, ring volume and ring weight parameters were compared with temperature and precipitation records.

Strong climate-tree growth relationships are indicated by numerous common marker years, strong cross dating between randomly selected individual cores and site summary chronologies, and by high correlations between tree-ring chronologies for sites hundreds of kilometers apart. The study demonstrated the complexity of these relationships suggesting that more sophisticated statistical treatment be applied in order to better establish climate-growth relationships. (Adapted from authors' abstract)

PETERSON, E.B., N.M PETERSON AND R.D. KABZEMS, 1982. Impact of climatic variation on biomass accumulation in the boreal forest zone: selected references. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 55 p. & anno. bibl.

ENFOR Project P-150

Comments: Well organized review with annotated bibliography. A useful basis for selection of future research on climatic impact on boreal forests.

Abstract: A literature review on relationships between climatic variables and growth rates of boreal tree species with emphasis on information from the boreal forest region in Canada. An annotated bibliography of 329 references provides background information for a synthesis of:

- climatic factors or processes that influence boreal biomass accumulation rates;
- non-climatic factors or processes that influence boreal biomass accumulation rates;
- influence of boreal biomass burning on atmospheric CO_2 levels;
- boreal climate-biomass relationships; and
- knowledge gaps.

In the synthesis, factors that influence growth rates of boreal tree species were grouped into those that could cause increases and those that could cause decreases in net primary productivity. Temperature related variables exert more obvious controls over primary productivity than do moisture-related variables.

Because there are many non-climatic factors that regulate boreal tree growth, forest productivity changes induced by climatic variation may be masked by the growth-controlling influences of topography (aspect), soil moisture and soil nutrients, ecological succession and forest fire history.

Important knowledge gaps concern the linkages between atmospheric circulation patterns and climatic conditions at regional levels.
(Adapted from authors' abstract)

CAMERON, D.A., 1981. Biomass production from the harvesting of a tolerant hardwood stand in Algoma, Ontario. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 23 p. & append.

ENFOR Project P-152

Comments: Demonstrates difficulties that may be encountered in initial trials of biomass harvesting.

Abstract: The feasibility of harvesting biomass for energy concurrently with a sawlog harvest from tolerant hardwood stands on an 11 ha operation in the Algoma region of Ontario was assessed. Along with a control four intensities of a chipping operation were integrated with a conventional sawlog operation: clearcut to two diameter limits, shelterwood cut to a diameter limit, shelterwood cut for sawlogs with chipping of unmerchantable portions, and cleanup of a previously logged area.

Large limby tops were difficult and slow to skid and were not handled efficiently by the chipper without further cutting. Some material was too large for the Morbark Chiparvester 22.

Total costs ranged from $44 to $64 per green tonne. Chip value was only $8.82 per tonne delivered, while sawlogs brought $145/M. Losses were encountered for all operations.

Unexplained discrepancies between cruise volume estimates and measured removals ranged from 13.5 to 65.6%. (Reviewer's abstract)

HARDWOOD COPPICE SILVICULTURE

ENFOR Project P-154; no published report available

Objective: To test several methods and concepts of coppice management and silviculture of existing hardwood stands and to evaluate their value and feasibility for biomass production.

Comments: Work on this project is still in progress.

POSTCUT MONITORING OF COMPLETE BIOMASS REMOVAL IMPACTS IN HARDWOOD STANDS.

ENFOR Project P-155; no published report available

Objective: To assess the environmental impacts of complete biomass harvesting on trembling aspen - white birch and maple - yellow birch stands. Site damages will be determined and corrective measures proposed that will reduce negative environmental impacts. The methodology developed under Project P-95 will be used. Regeneration surveys will also be done to evaluate future biomass production on both silviculturally treated and non-treated areas.

Comments: Work on this project is still in progress.

LUSSIER, LOUIS-JEAN AND JACQUES MARANDA, 1982. Perspectives d'utilisation de la biomasse forestière au Québec. Can. Dep. Environ., Can. For. Serv., Laur. For. Res. Cent., Inf. Rep. LAU-X-52. 55 p. & append.

ENFOR Project P-157

Comments: A useful report for those interested in the general planning of biomass programs, or in the Quebec situation in particular.

Abstract: In Quebec, the availability of forest biomass is assessed by management zones and administrative regions. This report examines current use (1981) of forest biomass, as well as quantities of surplus biomass by biomass source and product category.

The uses of surplus biomass over the next decade are forecasted and possible conflicts between current and future uses are analyzed.

The total above-ground wood biomass available annually, in Quebec's forests, is 35 million m^3 and 15 million oven-dry metric tonnes under extensive management. Logging residues represent 10% of this quantity, merchantable full trees 60% and unmerchantable trees 30%. (Authors' abstract)

METHVEN, IAN R., 1982. Biomass prediction equations for young red pine (Pinus resinosa Ait) plantations in the Maritime Lowlands ecoregion. Can. Dep. Environ., Can. For. Serv., Contractor's Draft Report. 17 p. & append.

ENFOR Project P-158

Comments: Empirical study restricted to untended red pine plantations in the Maritime Lowlands.

Abstract: Linear equations were developed for estimating biomass component weights of untended red pine plantations.

Best estimators were found to vary according to age class and biomass components. For trees 1 to 5 years old, the best estimators of full-tree weight were crown width (CW) and the product of crown width and crown length (CW x CL). The correlation coefficients were 0.6206 and 0.6112 respectively. For trees 11 to 15 years old, the best estimators of full-tree weight were $(DBH)^2$ and $(DBH)^2H$, with correlation coefficients of 0.8285 and 0.8173 respectively. For trees 16 to 20 years old, the best estimators were $(DBH)^2H$ and $(DBH)^2$, with correlation coefficients of 0.7505 and 0.7268 respectively. The correlation coefficients were generally lower and standard errors of estimates were higher than in other studies. This was due to the high mortality and varied spacing found in some of the untended plantations. (Reviewer's abstract)

DEVELOPMENT OF REGIONAL BIOMASS PREDICTION EQUATIONS FOR SEVEN MAJOR COMMERCIAL TREE SPECIES IN NEW BRUNSWICK AND NOVA SCOTIA

ENFOR Project P-159; no published report available

Objective: To establish the data base for the development of regional and sub-regional biomass equations for seven major commercial tree species. This will involve the determination of green and oven-dry weights of whole trees and component parts of balsam fir, red/black spruce, white spruce, jack pine, red maple, aspen and white birch using standard methodology. The long range objective is to develop biomass equations that will be useful to the provincial forest services of New Brunswick and Nova Scotia for converting conventional inventory data to biomass estimates.

Comments: Work on this project is still in progress.

NAGLE, GEORGE S., 1980. Analysis of salvage yarding systems and costs in Pacific coast forests. Can. Dep. Environ., Can. For. Serv., Pac. For. Res. Cent., Inf. Rep. BC-X-214. 30 p. & append.

ENFOR Project P-162

Comments: A review of literature to determine the availability of forest residue and harvesting costs. Theoretical methods of improving residue harvesting systems are presented.

Abstract: The objective of this study was to review and analyze existing cost estimates for harvesting forest residuals to guide development of new equipment and systems. Major problem areas identified were piece size and accessibility. Thirteen separate studies were reviewed in detail, providing a range of yarding costs from $5-$70 per bone dry tonne, depending on utilization standards and accessibility. On the basis of the analysis done for this report, about 2 million bone dry tonnes per year are estimated to be available in British Columbia at a cost not exceeding $30/tonne at roadside. This represents about 50% of available material. New technology will be required to harvest the remainder. (Author's abstract)

COBAN INSTITUTE, 1981. Costs of harvesting aspen stands for energy production. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 22 p. & append.

ENFOR Project P-163

Comments: Useful new data are presented, but significance is somewhat restricted to specific methods and conditions.

Abstract: The purpose of this report was to determine production and cost data which would assist resource managers to make rational decisions concerning the utilization of aspen for energy production.

Two aspen sites were selected on the Rocky Mountain Grazing Reserve situated 30 km west of the town of Rimbey, Alberta. Site #1 contained 3.8 ha of 37 year old aspen; site #2 contained 4.9 ha of 58 year old aspen. The aspen was logged and chipped by the full tree harvesting system. Felling was carried out by chain saw and Dika Side Cutter. A Nicholson 22 Complete Tree Utilizer (C.T.U.) was used to chip the aspen.

The data indicated that it is unlikely that wood gas derived from full tree aspen chips will prove economically competitive with natural gas until 1983. (Author's abstract)

D.A. WESTWORTH & ASSOCIATES LTD., 1981. A study of the impact on wildlife of short-rotation management of boreal aspen stands. Can. Dep. Environ., Can. Wildlife Serv., Contractor's Interim Report. 24 p.

ENFOR Project P-164

Comments: Relevant study which assessed the effect of rotation length on wildlife habitat. Further study was done under Project P-203.

Abstract: Study plots were located in stands of 12, 30, and 60 year old aspen-dominated stands to determine their browse productivity, browse consumption, and bird use. Early findings were that browse use by ungulates was highest in the 60 year old plot, even though browse production was lowest in this stand.

Snowshoe hare browse was heaviest in the 12 year old stand where rose, a preferred food, was most abundant.

Snags, particularly the older ones found in the 12 year old fire-origin stand, may prove to be an important habitat element for certain birds. (Reviewer's abstract)

POLLOCK, WILLIAM S. AND JEAN DENIS LEBLANC, 1981. Biomass equations for NWT and northern parts of Prairie Provinces: data acquisition phase. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 14 p. & append.

ENFOR Project P-169

Comments: This report describes the sampling procedures used. The final report will present the biomass prediction equations and an analysis of specific gravity of all the sample trees.

Abstract: This paper summarizes the data collection phase for the development of predictive component biomass equations for the six major tree species in the Northwest Territories. Additional sampling was carried out for the forest fire research and climatological studies.

Green weights were obtained for tree components by field sampling a wide range of tree sizes. Oven-dry weights were obtained of component sub-samples.

Three hundred and thirty-six trees were sampled from 3 locations. The data were transferred to magnetic tape which will be used by the CFS to develop the equations. (Authors' abstract)

COULOMBE, RODRIGUE AND ANDRE B. LEMAY, 1982. Evaluation of potential interactions between forest biomass production and Canadian wildlife. Can. Dep. Environ., Can. Wildlife Serv., Contractor's Report. 262 p. & append.

ENFOR Project P-170

Comments: General concepts are reviewed. The problems identified are similar to those encountered in conventional forest harvesting.

Abstract: Forest management for biomass production can be undertaken in all provinces of Canada. Raw material can be extracted either from sawmills, logged areas, silvicultural treatments, or short-rotation intensive culture. All forests are suitable habitats for wildlife. However, some species (woodland caribou, lynx, marten, owl..) are extremely dependent on mature forests. Management of second growth forests should take into consideration these species by extending rotations so part of the forests will serve these species. Removal of snags and downed logs to increase amount of raw material will contribute to reduce habitats of, for instance, tree-nesting birds. As these aspects have not been intensively studied within the Canadian forest regions, interactions can hardly be specified. Studies are recommended to analyse the overall problems and define measures to prevent detrimental effects. Other species (rare, threatened or endangered) will need specific attention and precaution while managing forests. Some are highly sensitive to noise and human disturbance (Whooping Crane, White Pelican, Peregrine Falcon...), others are very sensitive to harassment. Increased human presence within managed forests will necessitate more educational programs to prevent detrimental effects. Some species of reptiles, amphibians and fishes are so poorly documented that only basic studies of the biology, ecology and distribution will permit to identify and evaluate interactions with these new forestry concepts. (Authors' abstract)

SALIX (WILLOW) FOR BIOMASS FUEL AND ENERGY CONSERVATION

ENFOR Project P-172; no published report available

Objective: *Salix* has a wide geographic range, is highly adaptable to various forest and non-forest soil types and has shown potential for high biomass yields. This research and development project will collect and screen the available propagation material, cultivate clones, and develop seed orchards with the goal of producing sufficient cuttings to plant trial plots for testing the success of various species and hybrids.

Comments: Preliminary investigations have been completed. Substantial further work is proposed.

DATA COLLECTION FOR DEVELOPING STAND AND SINGLE-TREE BIOMASS FUNCTIONS FOR NATURALLY GROWN EASTERN WHITE PINE, RED PINE, EASTERN WHITE CEDAR, EASTERN RED CEDAR AND TAMARACK IN ONTARIO

ENFOR Project P-179; no published report available

Objective: To obtain biomass and stem measurements for five naturally grown species in Ontario by destructive sampling. Data will be used to develop single tree biomass estimating equations.

Comments: Articles on aspects of this project have been prepared for scientific journals by Dr. I.S. Alemdag, Petawawa National Forestry Institute. A comprehensive final report is proposed. The project is closely related to P-234, which is still in progress.

PREPARATION OF A REPORT ON PROJECT P-21

ENFOR Project P-182

Comments: Report completed and released under Project P-21.

P-183

FURTHER DEVELOPMENT OF LOGGING RESIDUE PROCESSING SYSTEMS

ENFOR Project P-183; no published report available

Objective: See title, above.

Comments: Work on this project is still in progress.

EVALUATION OF NET BIOMASS HARVESTING AND PROCESSING COSTS WHEN SITE REHABILITATION IS CONSIDERED A BENEFIT

ENFOR Project P-184; no published report available

Objective: To evaluate the productivity and costs of harvesting and processing, by non-conventional means, residual biomass on wet belt cedar - hemlock sites in interior British Columbia. Also, to establish the impact of reduced site rehabilitation costs and regeneration costs on the net costs of harvesting residual forest biomass.

Comments: Work on this project has been completed.

DEVELOPMENT OF TABLES TO ESTIMATE GREEN AND OVEN-DRY WEIGHTS FOR VARIOUS SPECIES

ENFOR Project P-186; no published report available

Objective: This is a small, in-house project of the Maritimes Forest Research Centre. The objective is to convert the equations for estimating tree biomass (ENFOR Projects P-4 and P-38) into tabular form.

Comments: Work on this project is still in progress. A report is expected in the near future.

PETERS, D.C., 1982. The economics of harvesting fuelwood under four different stand conditions on Prince Edward Island. Can. Dep. Environ., Can. For. Serv., Mar. For. Res. Cent., Inf. Rep. M-X-139. 7 p. & append.

ENFOR Project: P-189

Comments: The report provides information on the costs of fuelwood harvesting.

Abstract: Selective harvesting using modified small-scale equipment was carried out in four stand types: immature (pole-size) tolerant hardwood, mature softwood/intolerant hardwood, mature softwood/tolerant hardwood, and immature softwood. The primary end product is fuelwood. Records of labor cost, volume extracted, equipment modification and maintenance cost, and market value of extracted wood are documented for each stand type. (Author's abstract)

TREE WEIGHT EQUATIONS FOR NEWFOUNDLAND

ENFOR Project P-190; no published report available

Objective: To collect green and oven-dry weight data for the development of biomass equations for whole tree and component parts. The sampling is confined to the six major tree species in eastern Newfoundland.

Comments: The final report for this project is to be published. See Project P-112 for related work.

BOWATER NEWFOUNDLAND LTD., 1982. Harvesting forest biomass as an alternate fuel. Can. Dep. Environ., Can. For. Serv., Contractor's Interim Report. 57 p. & append.

ENFOR Project P-191

Comments: Interim report. Analysis of Phase II is planned by the Newfoundland Forest Research Centre.

Abstract: Interim report evaluates a system for harvesting and processing forest residuals and residue from conventional pulpwood cutovers. Ongoing production capacity should range from 110 to 120 green tons per day with costs of $28 to $30 per green ton. With an expanded system capable of utilizing the full chipper capacity, production could be increased to 190 to 200 green tons per day at a unit cost of approximately $25 per green ton. Boiler efficiency was increased from 40-50% to 60-65% when bark and wood chips were mixed in a 4:1 ratio. Conservatively, forest biomass was found to be equivalent to 1.1 to 1.3 barrels of oil per green ton. Phase II will study the economics of harvesting biomass in conjunction with pulpwood production. (Reviewer's abstract)

REGENERATION ASSESSMENT AFTER COMPLETE TREE REMOVAL

ENFOR Project P-193; no published report available

Objective: In 1976 a complete tree harvesting trial was carried out in a boreal mixedwood stand. The objective of this project is to survey regeneration five years after cutting and to assess the effects of complete tree removal on regeneration. Also, weight measurements for tree components of trembling aspen and alder will be collected.

Comments: The final report for this project is in preparation.

EXPERIMENTAL PLANTATIONS OF ALNUS SPECIES FOR ENERGY PRODUCTION

ENFOR Project P-194; no published report available

Objective: To determine the potential of Alnus glutinosa and A. crispa for biomass production on short rotation. Half of the seedlings will be innoculated with nitrogen fixing organisms. Survival, growth, biomass production and nitrogen fixation efficiency will be assessed during the three years following planting.

Comments: This is a long-term study which is still in progress.

KIMMINS, J.P., 1983. FORCYTE 10. A user's manual. Can. Dep. Environ., Can. For. Serv., Contractor's Report.

ENFOR Project P-197

Comments: This project is the largest environmental impact study of the ENFOR Production Program. The "User's Manual" includes a description of project objectives and earlier developments.

Abstract: An ecosystem-based forest management model (FORCYTE 10) was designed to examine the long-term consequences of intensive forest management on site nutrient capital, biomass production, and the economic performance and energy efficiency of alternate management scenarios. The model was developed to use nitrogen data, however, any other single nutrient can be examined if the data are available and changes are made to the model. The model consists of two programs that run sequentially. The first predicts and graphs biomass trends and biomass and nutrient turnover over time for plant components growing on various sites. The model can simulate over a wide range of management alternatives, assuming the initial site quality.

The second program uses these trends to predict the development of the biomass ecosystem components over time for any chosen initial site quality and for site quality varying with time according to the circumstances described in the simulation. Ecosystem productivity in the model depends on the availability of the simulated nutrient, which in turn depends upon the simulated nutrient cycling, and most of the nutrient concentrations change as site quality changes.

The model permits the forest manager to examine the consequences of rotation length, regeneration delays, species selection, initial stocking density, spacing, various intensities of thinning and fertilization, and the utilization level at intermediate and final harvest.
(Adapted from author's abstract)

FORTIN, ANDRÉ J., 1982. Uses of nitrogen fixation and other root symbioses for biomass production. Can. Dep. Environ., Can. For. Serv., Contractor's Progress Report. 90 p.

ENFOR Project P-198

Comments: Progress report for a research project. No results yet.

Abstract: This report describes the work during the first year of a two year project. The work is a continuation of earlier research on nitrogen fixation and other root symbioses. This project will study the organisms and processes involved and their relationships with vegetation and soil components. These experiments will hopefully lead to an understanding of how to use nitrogen fixation and mycorrhizal symbioses on intensively managed plantations to yield increased biomass production while maintaining soil fertility, with minimal fertilization. (Adapted from author's introduction)

HENDRICKSON, O., J.B. ROBINSON, AND L. CHATARPAUL, 1982. The microbiology of forest soils: a literature review. Can. Dep. Environ., Can. For. Serv., Petawawa Nat. For. Inst., Inf. Rep. PI-X-19. 75 p.

ENFOR Project P-199

Comments: This literature review is the first stage of a long-term research project on the impact of biomass harvesting on soils.

Abstract: This report discusses the activities of two major groups of forest soil microorganisms, the bacteria and fungi. Special attention is paid to their participation in the decay of major forest litter substrates, including leaves, branches, and roots. The influence of bacteria and fungi in symbiotic associations with woody plant roots upon the cycles of carbon and nitrogen is described. The impacts of certain forest management alternatives are assessed in terms of the creation or elimination of suitable environments for the activity of soil microorganisms. (Authors' abstract)

DESIGN AND FABRICATION OF A BUNDLE-TYING DEVICE FOR THE MINI-ROTATION HARVESTER

ENFOR Project P-201; no published report available

Objective: To design and build a bundle-tying device and incorporate it into a mini-rotation poplar harvester and to field-test the bundling attachment to determine operational capabilities.

Comments: The bundle-tying device was not constructed.

IMPACT ON WILDLIFE OF SHORT-ROTATION MANAGEMENT IN BOREAL/ASPEN STANDS

ENFOR Project P-203; no published report available

Objective: This study is a continuation of ENFOR Project P-164 and its objective is to assess the effects on wildlife of the increased utilization of young aspen stands for biomass. This requires the development of capabilities to predict species types, population densities, forage production, and availability of suitable wildlife habitats. Patterns of stand utilization by mammals and birds will also be determined.

Comments: Work on this project is still in progress.

DETERMINATION OF BIOMASS AND NUTRIENT CONTENT IN TREES, GROUND, VEGETATION AND SOIL OF ASPEN STANDS IN THE PRAIRIE PROVINCES

ENFOR Project P-205; no published report available

Objective: To collect and analyze tree component parts, herbs, shrubs, litter and soils for nutrient levels. Concurrently, biomass data will be obtained for the roots, herbs, shrubs and litter. The information will be utilized as the data base for the Kimmins model.

Comments: Work on this project is still in progress. A report is expected in 1984.

WOODLAND RESOURCE SERVICES LTD., 1982. Development of an integrated operation for aspen wood products and energy from aspen biomass. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 149 p. & append.

ENFOR Project P-207

Comments: An example of a feasibility study. The results are discouraging.

Abstract: ENFOR Project evaluated the conventional harvesting and processing methods for aspen (Populus tremuloides) in the Slave Lake area of Alberta. Base data gathered from the actual harvest and milling of 600 m^3 of aspen were used in developing and analyzing 13 mill design models to determine the optimum economic mix of wood products, including energy produced from easily recoverable aspen biomass. The results clearly indicate that the rates of return on investment are extremely sensitive to fluctuations in conversion factors, log costs, energy costs and lumber selling prices.

The best indicated utilization of aspen, in terms of economic return, is in a stud lumber plant utilizing purchased energy and having an annual production capacity of 150,000 Mfbm/A of lumber. A 15 percent reduction in the selling price of studs will reduce the rate of return from 23 percent to 10 percent. Under the present economic conditions, none of the proposed mills is economically attractive. A rate of return of 30 percent, with little sensitivity to key variables, is necessary to attract capital to the forest products industry. (Adapted from author's abstract)

DEVELOPMENT OF THE RECUFOR LOGGING RESIDUE PROCESSOR

ENFOR Project P-210; no published report available

Objective: To design and manufacture a mobile logging residue processor and to test it to ensure that it is free of major faults.

Comments: This project is completed. A report will be available in the near future.

P-211

PREPARATION OF A REPORT ON PROJECT P-152

ENFOR Project P-211

Comments: Report completed and released under Project P-152

APPLICATION OF THE RECUFOR ROTOR TO COMMINUTION OF RESIDUES AT LANDINGS AND PROCESSING PLANTS

ENFOR Project P-215; no published report available

Objective: To build and test a machine for processing residue from the delimbing and topping of full trees at the roadside and landings. The machine is to incorporate the Recufor rotor for comminution.

Comments: Work on this project is still in progress. See related studies under P-28, P-210 and P-243.

DEVELOPMENT OF A ROLL-SPLITTER

ENFOR Project P-216; no published report available

Objective: To refine the roll splitter concept and build and test a prototype.

Comments: A prototype was built and the concept proved. A report is in preparation.

T.M. THOMSON AND ASSOCIATES LTD., 1981. A survey of ENFOR biomass estimation projects. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 126 p. & append.

ENFOR Project P-219

Comments: This is an overview prepared for use in the management of the ENFOR Program. It includes a systematic description of the data collected in ENFOR biomass inventory projects.

Abstract: All ENFOR projects concerned with the estimation of biomass are reviewed and their contribution to a national forest biomass inventory is assessed. A summary of the measurements taken, of the range of samples and of the main results is presented for each project completed or under way in March 1981. Recommendations for future work are made. (Reviewer's abstract)

DEVELOPMENT OF A MECHANIZED BRUSH HARVESTER

ENFOR Project P-223; no published report available

Objective: This is a continuation of Project P-27. Its objectives are the same.

Comments: Work on this project is still in progress under Project P-231.

INTERGROUP CONSULTING ECONOMISTS LTD., 1982. Availability and cost of forest biomass in Canada. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 73 p. & append.

ENFOR Project P-224

Comments: A national overview of the supply and delivery costs of forest biomass is presented. These estimates would be useful in setting national policy and priorities. They are not precise enough to be useful at the regional level.

Abstract: This study has investigated and reports on the availability of forest biomass in Canada in 38 separate regions and in a series of biomass categories including mill residues, biomass associated with harvesting of surplus timber stands, biomass derived from salvage operations and conversion of undesirable stands for rehabilitation purposes, and biomass produced under intensively managed plantation conditions.

The results of the analysis indicate that forest biomass in Canada represents an immense renewable resource of relevance for large scale energy conversion in most of the study's 38 regions. Commercial exploitation of this alternative energy resource is limited at present to the readily available, low-cost mill residues with most other biomass categories not being touched even though much biomass in these categories also could be assembled at conversion centres at economically attractive delivered costs.

The total potential supply of forest biomass in all regions and categories in Canada is estimated at about 112 million oven dry tonnes (ODt) per year with this total expanding slightly to about 120 million ODt by the year 2000. Approximately three-quarters of this biomass could be delivered to conversion centre locations at prices of $45/ODT or less. Several of the regions considered, particularly in British Columbia, Alberta, Ontario and Quebec, offer sufficient biomass supplies to meet the requirements of large scale energy conversion at delivery prices of $30/ODt or less. (From author's executive summary)

DEVELOPMENT OF BLACK SPRUCE BIOMASS EQUATIONS FOR QUEBEC

ENFOR Project P-225; no published report available

Objective: To develop biomass estimation equations for black spruce in Quebec. A secondary goal is to determine the ideal sample size to achieve the best results.

Comments: The data collection is completed and the analysis is still in progress.

ENVIRONMENTAL APPLICATIONS GROUP LTD. AND NORTHLAND ASSOCIATES LTD., 1982. Impact potentials of intensive forest biomass production (plantations) on reptile and amphibian populations of southern Ontario and Quebec. Can. Dep. Environ, Can. Wildlife Serv., Contractor's Interim Report. 28 p.

ENFOR Project P-226

Comments: Initial report on study to consider impact of intensive management on reptiles and amphibians.

Abstract: A methodology for assessing the potential impacts of forest biomass production (primarily hybrid poplar, but also willows and other species) on reptiles and amphibians of the region, based on a system of terrain units, as presented.

Areas where hybrid poplar production is most likely to take place are in eastern Ontario and the Niagara area. Maximum planted areas at each location are projected at approximately 20,000 acres by the year 2000. Lands utilized would be mostly class 3-5 agricultural capability lands.

Habitats most suited to reptiles and amphibians are those containing abundant wetlands, frequent rocky outcrops, sandy soils, and abundant surface debris.

Findings to date suggest that the potential for impacts of intensive forest production (plantations) on reptile and amphibian populations of the region is low, but further efforts are required before any definitive statements can be made. (Authors' abstract)

COORDINATION OF ENFOR BIOMASS ESTIMATION PROJECTS AND DEVELOPMENT OF BIOMASS ESTIMATES BASED ON PROVINCIAL TIMBER INVENTORIES

ENFOR Project P-227; no published report available

Objective: To coordinate, at a close technical level, the development of biomass estimation equations and their application to the forest inventory data of all provinces in order to generate forest biomass estimates according to specifications of the Canadian Forest Resource Data System. The establishment of national and regional data bases for the storage of biomass data gathered on ENFOR projects is also planned.

Comments: Work on this project is still in progress at Forestry Statistics and Systems Branch, Chalk River, Ontario.

CHARLES G. TURNER AND ASSOCIATES LTD., 1982. Feasibility study on the conversion of an oil/gas heating plant at CFB Borden to a biomass fuel plant. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 44 p.

ENFOR Project P-228

Comments: A feasibility study of local interest.

Abstract: The study determined the feasibility of supplying wood fuel to a wood-fired boiler at Base Borden. Several sources were investigated including logging and milling residues, the harvesting of natural forest materials and biomass production from future hybrid poplar plantations. While each source would have the capacity to supply sufficient biomass and would be technically possible, the economics at this time indicate that only the mill waste is a viable source of supply.

The economics of burning wood waste are not favourable in comparison to gas firing. The increased capital cost and labour costs are not offset by the lower fuel cost. (Adapted from author's conclusion)

DEVELOPMENT OF A MECHANIZED BRUSH HARVESTER

ENFOR Project P-231; no published report available

Objective: This is a continuation of Projects P-27 and P-223. Its objectives are the same.

Comments: Work on this project is still in progress.

TRANSFER OF NITROGEN FIXING ABILITY FROM ALDER TO BIRCH

ENFOR Project P-232; no published report available

Objective: To establish why alder can accept certain organisms in symbiotic relationship, but birch cannot.

Comments: Interim report will be available at Petawawa National Forestry Institute in April 1983.

ENERGY PLANTATIONS AND SOIL NUTRIENT LEVELS

ENFOR Project P-233; no published report available

Objective: Maintenance of some plantations established under the ENFOR Program.

Comments: This is the continuation of Projects P-10 and P-75.

STEM MEASUREMENT AND MASS DATA COLLECTION FOR FIFTEEN NATIVE HARDWOOD SPECIES IN ONTARIO

ENFOR Project P-234; no published report available

Objective: To obtain biomass and stem measurement data for fifteen hardwood species in Ontario by destructive sampling. Data will be used for the development of single tree biomass estimating equations.

Comments: Data collection will be completed in 1983. A report will follow.

BIOMASS EQUATIONS FOR QUEBEC

ENFOR Project P-236; no published report available

Objective: To develop single tree biomass equations, compatible with the Quebec forest inventory data bank, by destructive sampling of all species which make up at least 5% of the province's forest inventory.

Comments: The data collection is completed and the analysis is in progress.

EQUIPMENT TEST AND SIMULATION MODEL FOR HARVESTING SMALL WOODLOTS

ENFOR Project P-237; no published report available

Objective: To construct a simulation model to compare North American and Scandinavian biomass harvesting equipment in terms of productivity and logistics in the context of small woodlots with low average diameter.

Comments: Work on this project is completed and a report is in preparation.

P-238

TRIAL CONVERSION OF CONVENTIONAL INVENTORY DATA TO BIOMASS DATA

ENFOR Project P-238; no published report available

Objective: This project involves an attempt to convert forest inventory estimates of New Brunswick into biomass estimates.

Comments: Work on this project is near completion. It has counterparts in Nova Scotia (P-247) and Newfoundland (P-240).

NORTHLAND ASSOCIATES LTD., 1982. Avalon biomass inventory pilot trial. Can. Dep. Environ., Can. For. Serv., Contractor's Report. 19 p. & append.

ENFOR Project P-240

Comments: This report describes procedures but does not give inventory results.

Abstract: The study was undertaken to develop and test suitable methods for estimating biomass of unmerchantable forest lands, and to determine if such biomass data collection can be combined with the regular volume data collection of merchantable stands and integrated into the provincial forest management inventory system.

During this two phase study, 2-man field survey crews collected biomass data from 94 cruise lines and 82 permanent forest management inventory plots (Phase 1), and from 301 temporary sample plots in non-commercial forest lands (Phase 2) within provincial Forest Management Unit 1.

The experience of this biomass inventory pilot trial suggests that it is possible to integrate collection of biomass data from both merchantable and unmerchantable stands. (Author's abstract)

P-242

A PILOT STUDY FOR THE CANADA BIOMASS INVENTORY

ENFOR Project P-242; no published report available

Objective: To fulfill the Forestry Statistics and Systems Branch mandate to complete a Biomass Inventory for Canada by 1984. This pilot project was initiated to convert the conventional inventory into a biomass inventory and estimate the biomass on non-conventional areas of Newfoundland and store the data in the Canadian Forest Resource Data System. The pilot study is also to develop and assess procedures, identify problem areas, and estimate costs and manpower requirements for the National Forest Biomass Inventory.

Comments: This pilot study has been completed and the results incorporated into the National Forest Biomass Inventory at Forestry Statistics and Systems Branch at Chalk River, Ontario.

OPTIMIZATION OF A RECUFOR ROTOR

ENFOR Project P-243; no published report available

Objective: To optimize the Recufor rotor/impeller system based on field test observation and to develop a final design of the Recufor rotor.

Comments: Work on this project is still in progress. See related work under Project P-28, P-210 and P-215.

REVIEW OF THE ENFOR PRODUCTION PROGRAM

ENFOR Project P-245; no published report available

Objective: To review and assess the accomplishments of the ENFOR Production Program in light of program and broader government objectives.

To identify problem areas and research topics warranting further investigation, and to recommend program strategies for responding to these needs.

To prepare an annotated bibliography and digest of ENFOR Production Program reports (including those contractors' reports not yet published).

Comments: This project has been completed. The third objective is the subject of the present report.

BIOMASS EQUATIONS FOR YUKON SPECIES

ENFOR Project P-246; no published report available

Objective: This project is a continuation of P-141. Its objectives are the same.

Comments: Work on this project is still in progress.

MACQUARRIE, G.P. AND F.G. MAJAESS, 1982. Biomass inventory for Nova Scotia: a pilot study. Can. Dep. Environ., Can. For. Serv., Contractor's Interim Report. 18 p. & append.

ENFOR Project P-247

Comments: Pilot study has defined the problems associated with the conversion of Nova Scotia's volume inventory to a biomass inventory.

Abstract: The report describes a pilot study undertaken in Nova Scotia to develop sampling techniques and methodology for converting forest volume inventories to biomass inventories.

Permanent Sampling Plot (PSP) and Multi-Stage Sampling (MSS) data were used to determine biomass yield by various diameter classes and tree components. A comparison of biomass estimates from the two sampling methods was done for Pictou County. Good correlation was found for trees larger than 10 cm dbh. A difference of about 50% occurred in the sapling estimate. This large discrepancy was attributed to the use of the MSS technique, which was not designed for sampling regeneration and young-aged stands. (Reveiwer's abstract)

APPLICATION OF AN INDUSTRIAL SLUDGE TO HYBRID POPLARS

ENFOR Project P-248; no published report available

Objective: To determine if the application of industrial sludge to hybrid poplar plantations is environmentally acceptable. Testing will include the determination of nitrogen uptake capacity, nutrient and heavy metal uptake, and growth response of hybrid poplars. Effects on the environment will be monitored through the analysis of nutrient and heavy metal concentrations on leachates and by determining the effects of high sodium concentrations on soil structure and permeability.

Comments: Work on this project is still in progress. A report is expected in 1984.